Annual report

Cornell University.
Agricultural Experiment Station

TWENTY-FIRST ANNUAL REPORT

OF THE

CORNELL UNIVERSITY

Agricultural Experiment Station

ITHACA, N. Y.

1908

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IN ASSEMBLY

JANUARY 15, 1909.

TWENTY-FIRST ANNUAL REPORT

OF THE

Agricultural Experiment Station of Cornell University

STATE OF NEW YORK:

DEPARTMENT OF AGRICULTURE,

ALBANY, *January* 15, 1909.

To the Honorable the Legislature of the State of New York:

In accordance with the provisions of the statutes relating thereto, I have the honor to transmit herewith the Twenty-first Annual Report of the Agricultural Experiment Station at Cornell University.

R. A. PEARSON,

Commissioner of Agriculture.

ORGANIZATION

Of the Cornell University Agricultural Experiment Station

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THE TRUSTEES OF THE UNIVERSITY

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P. J. WHITE, Farm Crops.
D. REDDICK, Plant Pathology.
E. R. MINNS, Farm Practice.
G. A. CRABB, Soils.

The regular bulletins of the Station are sent free to persons residing in New York State who request them.

November 30, 1908.

The Governor of the State of New York, Albany, N. Y.,
The Secretary of the Treasury, Washington, D. C.,
The Secretary of Agriculture, Washington, D. C.,
The Commissioner of Agriculture, Albany, N. Y.:

The Act of Congress, approved March 2, 1887, establishing Agricultural Experiment Stations in connection with the Land Grant Colleges, contains the following provision: "It shall be the duty of each of said stations, annually, on or before the first day of February, to make to the governor of the state or territory in which it is located, a full and detailed report of its operations, including a statement of receipts and expenditures, a copy of which report shall be sent to each of said stations, to the said Commissioner of Agriculture, and to the Secretary of the Treasury of the United States."

And the Act of the Legislature of the State of New York, approved April 12, 1906, providing for the administration of the New York State College of Agriculture at Cornell University contains the following provision: "The said university shall expend such moneys and use such property of the state in administering said college of agriculture as above provided, and shall report to the commissioner of agriculture in each year on or before the first day of December, a detailed statement of such expenditures and of the general operations of the said college of agriculture for the year ending the thirtieth day of September then next preceding."

In conformity with these mandates I have the honor to submit on behalf of Cornell University the following report:

The dedication of the new buildings of the College of Agriculture made the year 1906–1907 a memorable one in the history of agricultural education in the State of New York. Accordingly in the Report for that year the whole subject was discussed at considerable length by the President as well as by the Director. It was recognized that the age called for cultivated intelligence and scientific methods in all branches of agriculture. The agricultural condition of the State was described as well as the efforts which the College of Agriculture was making to improve that condition. The liberal appropriations made by the last Legislature enable the College to continue and augment those efforts. Besides the regular fund of $150,000 for maintenance in the appropriation bill, the supply bill carried special appropriations

of $30,000 for glass houses and $10,000 for extension work on farms and with farmers.

But the great event of the year for the College of Agriculture was the purchase by the University of additional farm land. The Legislative Act (chapter 655 of the Laws of 1904), appropriating $250,000 for buildings for the New York State College of Agriculture at Cornell University, contained the provision that "nothing in this act shall be construed to relieve Cornell University of any of its obligations to the State to provide for instruction in agriculture or otherwise and the provisions of this act are intended to provide additional facilities therefor." Recognizing this obligation the Trustees of the University have ever had in mind the needs and requirements of the College of Agriculture and so far as has been possible they have endeavored to provide for those needs. An enlargement of the University farm was earnestly recommended, first by Director Roberts and, since, by Director Bailey. The President strongly indorsed these recommendations but the Trustees, while concurring therein, were not agreed that the time for action had arrived. The increase, however, in the number of students in the College of Agriculture, the erection by the State of large buildings for the use of the College, and the generous provision made by the State for its support, all combined, along with the continuously increasing inadequacy of the present farm, to convince the Trustees that additional lands should be secured at once, especially as local conditions were at the moment particularly favorable for purchase. The matter was accordingly referred to a committee with the result that a number of farms were purchased from different owners, which, in combination with former holdings, gives the New York State College of Agriculture 579 acres for farming purposes, besides providing 100 acres for the New York State Veterinary College for an experimental station for sick animals.

Now that the University has greatly enlarged its farms, it will be possible, if State funds are available, to add to the live stock of the College, which is needed as material both for demonstration to students and research by professors. New York State produces about one-ninth of the hay and forage of the United States, and the animal industries of the State are of enormous value. This is a field, therefore, to which the instruction and investigation of the College should be peculiarly directed, and the State appropriation of $25,000 for barns has solved the problem of housing facilities as the purchase by the University of land has solved the problems of pastures and fodder.

The work of the College of Agriculture and of the Federal Experi-

ment Station at Cornell University is very varied and extensive. For a complete description of it I beg to refer you to the accompanying reports of the Director and the heads of the several departments, which are to be regarded as an integral part of this report. Instruction and research in agriculture are necessarily expensive. The Federal Government holds the Stations to strict accountability for all their expenditures, which are regularly reported with expenditures itemized. This report includes a statement of the expenditure of State funds, which are all carefully guarded by the State Commissioner of Agriculture. The list of the staff of instruction in the New York State College of Agriculture and the Federal Experiment Station on September 30, 1908, is also given. And for further information there are appended the series of bulletins of the Agricultural Experiment Station, Nos. 250 to 258 inclusive, the Agricultural Experiment Station circulars, Nos. 1 to 3 inclusive, the Cornell Reading-Course for Farmers leaflets, Series VIII, Nos. 36 to 40 inclusive, the Cornell Reading-Course for Farmers' Wives leaflets, Series VI, Nos. 26 to 28, the Home Nature-Study Course leaflets, new series, Vol. IV, Nos. 1 to 4 inclusive, and the Cornell Rural School leaflets, Vol. I, Nos. 2 to 9 inclusive.

The departmental reports may be summarized as follows:

1. *Department of Farm Crops.*— Probably the greatest immediate returns for the money invested in this department are secured from the farm survey work which is directed (1) to the study of specific crops and (2) to the study of farming as a business. Under the first head forty-seven co-operate experiments in testing grass mixtures and in the methods of treatment of pastures have been started and the department is now taking up the study of pasture conditions throughout the State preparatory to increasing the number of experiments in this line. Experiments have also been undertaken to determine the cause and remedy for clover crop failures but the most important research work of the year was the agricultural survey of Tompkins county, of which the field work is now practically completed, and it is proposed to extend this work to other sections of the State covering areas which will represent most of the types of farm conditions in New York. This work is of the second type mentioned above.

This department gave instruction to 203 registered students during the year while in the field of extension work the staff devoted about one-fourth of its time to answering farmers' letters in addition to giving numerous lectures at farmers' meetings. A large number of

co-operative experiments were also carried on with farmers throughout the State, including 229 new experiments started during the year and 212 others continued from the previous year.

II. *Department of Farm Practice.*— The investigations being conducted by this department consist of experiments with fertilizers for mangel-wurzel, a comparison of the cost of producing dry matter in crops grown for silage and in root crops, and a study of the durability of roofing materials used on the College farms. Co-operative experiments (total 126) have also been conducted with seventy-five farmers along the following lines: Potatoes, test of varieties; corn, tests of varieties; soybeans, grown in corn for silage; spraying for the destruction of wild mustard; a test of mangels as a substitute for purchased concentrated feeds. The purchase by the University of additional farm lands, as mentioned above, will add greatly to the facilities of this department but like nearly every other department in the College, it is seriously cramped for room in which to carry on the work of instruction to students.

III. *Department of Experimental Plant Breeding.*—As this department was not organized until April, 1907, the experiments have been under way but one season but a number of investigations have been started which should prove of great value to the agricultural interests of the State. New York is a State of diversified agriculture but the hay crop far outranks all others in total acreage and value of product, reaching in 1907 a total of 4,717,000 acres with a valuation of $93,388,-000. Timothy constitutes much the larger portion of the hay crop and probably greatly exceeds in value any other crop grown in the State. Accordingly the efforts of this department have been directed toward the improvement of this crop by proper methods of breeding and selection, looking not only to increased productivity, but also to the development of rust resistant varieties, this disease having wrought considerable damage to the crop during the past year in every section of the State. It is of course too early to look for definite results from this work but the progress of the experiments thus far gives every reason to believe that improved varieties will result which will be of great value.

In like manner experiments have been undertaken looking to the production of early races of dent corn, this being recognized as the most important problem in corn-breeding in New York, while still other investigations have in view the improvement of the oat, wheat, and potato crops, and of other forage crops than timothy. But the line of scientific investigation that is receiving most attention is the study

of variation, which lies at the foundation of all breeding work, and these studies are being supplemented by investigations on the laws of heredity in hybridization, the cumulative action of selection, and the influence of environment in species and variety formation.

The extension work of this department is expected to be limited but a number of lectures have been delivered before farmers' meetings and co-operative breeding experiments have been arranged with about twenty-five farmers in various parts of the State.

IV. *Department of Plant Physiology.*—Both the teaching and investigation work in this department began February 1, 1908. The department receives no Federal funds for research but it is hoped to make investigations, both fundamental and practical, an important phase of the work. The special lines now receiving attention are (1) observations on environmental factors in relation to the growth of field crops, (2) a fundamental study of the effects on the plants of environmental factors by isolation methods, (3) shade tent investigations to determine the effects of shading on the minute structure and composition of plants, (4) stimulation experiments by the use of non-nutrient salts, (5) nitrogen fixation by fungi, etc.

V. *Department of Plant Pathology.*—The research work of this department has been directed toward the further investigation of grape diseases, particularly the black-rot of grape, the base of operations having been changed from the Lansing vineyards to other infected vineyards in the vicinity of Romulus. The investigator in charge was on the ground throughout the entire season and much valuable data has been collected regarding dissemination, infection, and methods of control. The investigation of diseases affecting the bean crop have also been continued, the field laboratory for this work being located on the farms of the Burt Olney Canning Company of Oneida, while considerable attention was also devoted to the study of the black-rot of gladiolas, the apple scab fungus, hollyhock diseases, the peach leaf curl, and fire blight in nurseries.

On the side of extension work the department has carried on a large correspondence with individual farmers throughout the State answering specific inquiries in regard to crop diseases, this correspondence approximating during some months as many as 200 letters per week. Much good has also been accomplished by the exhibits which have been made at the State and county fairs, which will hereafter be a fixed feature of the extension work in all departments.

VI. *Department of Soils.*—In addition to giving instruction to 166 registered students during the College year, this department has been

conducting investigations into several problems of fundamental importance in soil management, notably the principles of soil granulation and some phases in the movement of soil moistures. But the most prominent form of activity of the department outside of University teaching is the extension work, which, while taking the usual form of correspondence and lectures, addresses and exhibits before farmers' meetings and at agricultural fairs, was largely concerned with the soil survey of the State. This work, fundamental as it is to practically every phase of farm and orchard investigation, strikes at the very basis of the proper understanding of the so-called "abandoned farm" problem of the State. Soil surveys on a scale of one inch equal to one mile were conducted in Livingston and Montgomery counties and on September 30th there had been mapped approximately 496 square miles of the former area and 284 square miles in the latter.

VII. *Department of Soil Investigation.*—The purpose of this department, established and administered in the spirit of the Hatch Act, is to conduct investigations into the principles underlying those properties of the soil that affect its productiveness. While in the course of these investigations some results will be obtained that will be of immediate benefit to farmers and others who are engaged in growing crops, the larger part of the returns will contribute to that knowledge of the properties of soils and their relation to plant growth, the possession of which is necessary for the intelligent conduct of the more immediately practical experiments. At present four main lines of investigation are being carried on, (1) the effect of moisture and temperature on the availability and utilization of plant nutrients in the soil, and the relation of this to crop production, (2) the influence of certain atmospheric conditions on the absorption of mineral nutrients by plants, (3) a study of certain unproductive soil with special reference to the activities of its bacterial flora, and (4) the character and concentration of the aqueous extract of a soil under different methods of treatment. A system of twenty-four concrete tanks of sufficient size to produce plants in a normal manner under approximately field conditions have been provided for these soil investigations.

VII. *Department of Horticulture.*—Under the supervision of this department the truck farm survey of Long Island begun a year ago was continued, this being, so far as known, the first systematic survey of vegetable growing to be undertaken by any experiment station. Long Island was selected as being the most favored region in the state for trucking and the data now accumulating promise to be of great interest and value to the men engaged in this industry. Inci-

dentally, too, in view of the thousands of acres in the interior of Long Island now producing nothing but scrubby growths of pine, oak, and chestnut, it is hoped to show that great opportunities here await the farmer of small means. The information gathered concerns soils, crops, methods, labor, harvesting, marketing, and the like. The department also worked in co-operation with the Department of Plant Pathology on the investigation of the black-rot of grape and one bulletin on this important question has been published giving the results of the experiments thus far, which show that the disease may be controlled by the use of fungicides. Other investigations included an inspection of peach yellow and little peach conducted during the summer in the orchards of the Youngstown district, Niagara county, while the studies commenced on the peony in co-operation with the American Peony Association four years ago have been continued. But perhaps the most important piece of work which this department has in hand is the Cornell orchard survey, this movement combining the features of a census and those of a biological study. Surveys of six counties have now been completed, namely, Wayne, Orleans, Niagara, Monroe, Ontario, and Orange, and it is proposed to extend still further this exceedingly important line of horticultural extension effort.

IX. *Department of Entomology*. The courses announced by this department had a total enrollment during the year of 378 students and in addition to carrying on this work of instruction several members of the staff have been engaged in the preparation of text-books for the use of students and general readers, including a "Manual of the Spiders of the United States," a book on "Insects Injurious to Fruits," a work consisting of tables for the identification of the insects of the northeastern United States, a text-book on "Insect Morphology," and a text-book on "General Biology." Other research work was concerned with insects and crustacea that serve as the food of fishes, and extensive studies of certain injurious insects, including the habits and life history of the Timothy joint-worm and other Isosomas infesting grains and grasses, with a view to devising a method to prevent the injury caused by these insects, a study of the apple-seed chalcis, grape-seed chalcis, and other seed-infesting chalcid-flies, a study of a new leaf-miner of the plum, etc. The extension work of this department consisted of an extensive correspondence regarding injurious insects, a few co-operative experiments with farmers in spraying, and attendance at fairs with exhibits of injurious insects.

X. *Department of Dairy Industry.*—The number of students enrolled in the various courses offered by this department more than doubled during the past year, the registration of regular students aggregating 368 as against 183 the preceding year. Instruction was also given to 143 additional students in the short winter courses, and in addition to this the extension work carried on by this department included a heavy correspondence with various residents of the State who were seeking information in regard to some phase of dairy work, addresses before farmers' institutes and granges, and the systematic testing of over 200 individual cows in 22 different herds for the purpose of demonstrating methods by which the farmer may discover which are his unprofitable cows, how to keep a record of individual animals, and how he may produce more milk. Research work has also been carried on along several lines, including experiments in the manufacture of Camembert cheese, and a careful scientific study of the fermented milk drinks now on the market in this country. Experiments in the manufacture of cheddar cheese have produced some very interesting results which have been used by the State Department of Agriculture as a basis for regulating the sale of this type of cheese, and considerable work has been done on methods for market milk inspection, including a practical demonstration locally which has resulted in a marked improvement in the quality of the milk coming into the city of Ithaca.

XI. *Department of Animal Husbandry.*—This department enrolled 166 regular students during the first term of the college year and 138 students during the second term, besides giving instruction to 265 short winter course students during the winter months. The research work comprised mainly feeding experiments, (1) to determine the usefulness of various artificial foods in raising calves without milk, (2) on the use of roots instead of concentrated foods in the production of milk, (3) on the utilization of skimmed milk in feeding pigs, (4) on the possibilities of profitable beef-production in New York State, (5) the economy of production of winter lambs, and, finally, a co-operative experiment has been inaugurated with feeders of lambs in Genesee county to determine, if possible, the causes of loss of lambs by apoplexy, which is common in that vicinity. The larger part of the extension work in this department is comprised in supervising the records of the production of pure-bred cows belonging to various herds, involving 1,265 Holstein cows and 11 Guernsey herds, 5 Jersey herds and 1 Ayrshire herd.

XII. *Department of Poultry Husbandry.*— This department gave instruction to 167 registered students during the year. For the first time investigational work was segregated from the work of instruction and was greatly strengthened thereby, two members of the staff giving practically their whole time to the eighteen investigational projects under way. Two bulletins were prepared for publication, one on the "molting of fowls" and the other on "use of grit," and under the head of extension work over 8,000 letters were written in response to inquiries on poultry subjects, and seven lessons on poultry were prepared for the Rural School leaflets, besides a number of addresses before farmers' gatherings.

XIII. *Department of Farm Mechanics.*— As this department but recently organized and is not yet fully established no investigations of any kind were attempted. During the coming year, however, there will be made a thorough investigation of spray nozzles which it is hoped will prove of much practical value. But next to giving instruction to students in farm mechanics, farm engineering, farm machinery, and allied subjects, the department will probably find its most important function in acting as consulting engineer for the farmers of the State in matters pertaining to the selection of their farm machinery. This, of course, is a phase of the work which will require the most delicate handling as the greatest care must be exercised to avoid injuring the trade of any manufacturer by carelessly condemning his goods without just cause, but on the other hand the farmers of the State will expect and may justly demand expert advice, and it is the policy of the department to issue no statements either derogatory or commendatory in regard to any implement or machine unless such statement is founded on facts obtained by accurate tests under thoroughly fair and fully specified conditions.

XIV. *Department of Agricultural Chemistry.*—The Department of Agricultural Chemistry enrolled during the year 48 regular and 75 special students in addition to 125 students from the short winter courses, who attended a course of lectures arranged for them. The experimental work conducted under the appropriation from the State fund consisted chiefly in making chemical analyses of materials sent in by other departments, including a large number of moisture determinations of farm crops grown for experimental purposes. There has also been a large increase in the number of requests from residents of the State for analyses of various materials as soils, fertilizers, feeds, insecticides, etc., and this work now takes most of the time of the assistant in the laboratory. During the coming year investiga-

tions on moisture and sulphur content of evaporated apples will be continued.

XV. The Farmers' Reading Course (maintained by State appropriation) enrolled during the past year 1,523 active readers, of whom 998 were new members of the course within the year. In addition to these there were 5,100 other readers not enrolled as active, making the total distribution of the Farmers' Reading Course leaflets 6,623. In addition to supervising these reading courses the department has provided a large number of lectures before farmers' organizations throughout the State, and close attention has also been given to certain phases of extension work in the schools of the State, especially in the introduction of agriculture into the country school and the high school.

XVI. *Department of Home Economics.*—As the College of Agriculture has been an experiment station for the farm so it is becoming an experiment station for the farm home. The Farmers' Wives Reading Course conducted under the supervision of the Department of Home Economics enrolled during the past year 23,709 readers. Attention has also been given to the organization of farmers' wives clubs, and there are now 31 active clubs, with a total membership of 900. But probably the most important new step taken by this department during the year was the inauguration of a regular four-year course in home economics as an outgrowth of the reading course and of the winter course in home economics which was established three years ago. The laboratory which has been equipped in preparation for this regular instruction in the problems of the home was not ready until February, 1908, so that no students were able to register for the four-year course last year, but two general courses which were offered in home economics in the second term had a registration of 36 students.

XVII. *Rural School Education and School Gardening.*—The major part of the work in this department is a correspondence course for teachers and children in rural districts which reached during the past year 41,000 school children and 4,000 teachers in New York State. As a basis for the educational work there were published each month the Cornell Rural School leaflets, one for teachers and one for children. The leaflet lessons covered not only general outdoor study for the younger children but also elementary agriculture for the pupils in more advanced grades. Attention has also been given to the organization of farm girls' clubs and farm boys' clubs throughout the State, the purpose of the department being to aid in every way pos-

sible the boys and girls living in the country, to give suggestions for the better handling of farm work, for better reading, and for better forms of amusement in and about the farm home. The instruction in school gardening found its best expression in the Chautauqua Summer School conducted by this department, the work there consisting, first, of general nature study and biology, and, secondly, school gardening and elementary agriculture. This work is carried on by the College of Agriculture in co-operation with the Chautauqua Institution, the latter bearing a portion of the expense, and 80 students were registered in the class during the past summer.

XVIII. *Home Nature Study Course.*— The subject-matter in this course has followed the suggestions contained in the syllabus of nature study issued by the State Department of Education, and covers the more important work of the fourth grade and some subjects in the fifth grade. There were issued during the year four leaflets and one supplement, making in all 128 pages, containing 76 nature study lessons and also detailed directions for planting and garden work.. Each lesson was accompanied by a statement indicating the object of the lesson, the material needed, and the best way to secure it, and in connection with the series of questions covering the observations which the pupils should make there was a paragraph giving the teacher the facts concerning the topic and suggestions as to the method of teaching it. For the present there is provision for only 5,000 copies of each leaflet, and the demand is so great that the entire issue is now called for with the exception of 250 copies which have to be reserved for the files. Indeed, it was found necessary in some cases to send only one leaflet for two pupils in many of the training classes.

XIX. *Department of Rural Art.*— The aim of this department is to bring to the people, particularly of the rural districts, a better understanding of the beauty of their home surroundings, and to train the individual in methods of landscape design. The courses offered are meeting with an increased registration of students as the department is becoming better known, but it is also the policy of the department to bring to bear as strong an influence as is possible in the improvement of rural school grounds. To accomplish this the department will publish, through the teachers' leaflets issued by the College of Agriculture, a series of short articles on "Rural Art — Its Meaning and Possibilities," in connection with which it is proposed to give practical demonstrations to selected schools in various counties of the State.

It will be observed, therefore, that the activities of the College of Agriculture continue to be maintained along the three well-marked lines of instruction to students who attend the College, extension work among the farmers of the State and their families as well as teachers in the schools, and investigation and experimentation both in the laboratories of the College and on selected farms throughout the State. The goal is an enlargement of agricultural knowledge, a better education for farmers, and scientific method applied to the organization of their industries.

That the College and Experiment Station are doing their work well, and that they are rendering a real and valuable service to the entire State is amply shown in these reports of the professors in charge of the several departments of study and investigation, but it should be stated that the facilities of the College, both in men and means, are now taxed to their full capacity by the greatly increased registration of agricultural students, and as the Director points out, it has already become a serious question whether in view of the present crowded condition of classrooms and laboratories it will not be necessary to consider soon the matter of limiting the number of students. This, of course, would be nothing short of a calamity for it is the function of the College to minister in terms of higher education to the agricultural needs of the whole State, and the institution would signally fail in its first duty if it should be forced to close its doors to any citizen of the State who is mentally and physically fitted to pursue and profit by its instruction. But here, at least, time and space have their fixed limits, and some such recourse will be necessary unless additional facilities are soon furnished both in teachers to carry on the work of instruction and investigation and in room in which this work may be conducted. It is hoped, therefore, that the legislature and the State, which are already so deeply committed to the support of this important work, will hear the appeal of the great rural interest of the State as they are expressed in these pressing needs of the New York State College of Agriculture.

Respectfully submitted,

J. G. SCHURMAN,

President of Cornell University.

REPORT OF THE DIRECTOR.

To the President of Cornell University:

Sir.— I herewith submit my report of the College of Agriculture for the year ended September 30, 1908. This report includes an account of the general operations of the Experiment Station part of the College for the year ended June 30, 1908. It consists of reports submitted by each of the separate departments, including the work of the departments in regular teaching, extension, and investigation, together with recommendations as to the most important needs of the departments for their best development.

These different departmental reports sufficiently indicate the status of the College and the main needs, without further comments from me. They all agree in showing that the College of Agriculture is now pressed almost to its fullest capacity by the numbers of students and by the demands for work in all parts of the State. In fact, the College is now confronted with the prospect of limiting the number of students. It will be unwise to accept a much greater number of students than we now have without an increased staff and additional facilities. The instruction is largely personal, the student himself working with the materials rather than merely receiving lectures and reciting from texts. It is of the utmost importance that this personal method be maintained and its effectiveness even increased, even if it becomes necessary to set an arbitrary limit to the number of students. I think that 500 regular, special and post-graduate enrollments should be the outside limit with the present staff and equipment, and this limit we shall probably reach or overpass this coming year. This number of students fills all the laboratories and lecture-rooms and consumes all the time and strength of the present instructing staff; the addition of the winter-course students taxes the accommodations quite beyond the possibility of doing the best work.

I think that these facts should be publicly known. The College is set by the State to serve the needs of the State; how fully we can meet these needs will depend on the extent to which the State provides the means.

Respectfully submitted,

L. H. BAILEY,

Director New York State College of Agriculture.

DEPARTMENT OF FARM CROPS.

The work of the Department of Farm Crops is of three kinds: (1) Teaching work; (2) Extension work; (3) Investigation.

TEACHING WORK.

The overcrowded condition of the laboratory made it impossible to get the work as well organized as was desired. This was particularly felt by the graduate students, who had no room in the department during the second term. This condition has now been partly relieved, but there is still insufficient room as is mentioned in a special report on that subject.

The following students were registered in the department:

FIRST HALF YEAR

	Students.	
Farm Crops, 11	33	
Farm Crops, 13	16	
Farm Crops, 15	16	
Graduates	8	
Graduates (in absentia)	2	
		75

SECOND HALF YEAR

	Students.	
Farm Management, 12	44	
Farm Crops, 111 (specials)	47	
Farm Crops, 14	13	
Farm Crops, 15	12	
Graduates	10	
Graduates (in absentia)	2	
		128
Total registrations for both terms		203

Number of hours of instruction given (registration multiplied by hours per week not including work of graduates):

First term	182
Second term	359
Total for year	541

Proposed changes in courses.— It was hoped that a course in Farm Management might be offered for specials this year, also an additional course in Forage Crops and one in Advanced Laboratory work. These courses all had to be postponed until next year, when it is hoped that there will be facilities and teaching force sufficient to offer them.

EXTENSION WORK.

Fifty-three per cent. of the salaries and running expenses of the department has been expended for extension work, if we include the surveys and co-operative experiments under this head.

About one-fourth of the time of the writer is required for answering farmers' letters and correspondence with co-operative experimenters. Professor White and the writer have spent five weeks lecturing at farmers' meetings. A total of twenty-three weeks of additional time of either Professor White or the writer has been spent in co-operative experiment work, survey work, attendance at fairs, and the like.

This department did not have sufficient funds to continue those lines of co-operative experiment work that required much expense. Some of these experiments were dropped and others were continued by the Department of Farm Practice. The following experiments were started during the year:

Alfalfa	123
Vetch	16
Clover	4
Pasture experiments (No. 110)	19
New seeding pastures	15
Old seeding pastures	13
Fertilizers for meadows	25
Farm accounts	14
	229

A considerable number of experiments were continued from last year, probably most of the following:

Alfalfa (two previous years)	171
Pastures	19
Clover	16
Bookkeeping	6

RESEARCH WORK.

Agricultural survey.— The most important research work being conducted by the department is the Agricultural Survey of Tompkins county. The field work for this survey is now practically completed. There is a very large amount of tabulation still necessary. This will probably be completed by the end of the present year.

Work on pastures.— About one-third of the improved farm lands of New York State is in pastures, but little attention has yet been given to pasture problems. The department has had a few pasture experiments running for a number of years. This year, 47 co-operative experiments of testing grass mixtures and methods of treatment were started. Professor White is now taking up the pasture question and making a study of pasture conditions in the State, preparatory to increasing the number of experiments in this line.

Clover failures.— Field experiments in the growth of clover on soils where it once grew but now fails, have been conducted for the past two years. A bulletin giving the results of this work is being prepared. The work was started by the writer and has been continued by a graduate student, Mr. Squiers. Other pieces of research work that have been conducted by students and which are worthy of publication, are:

"The Incomes of 194 New York Farmers," by Mr. M. C. Burritt.

"Correlations of Certain Characters in the Maize Plant," by Mr. C. E. Craig.

"The Study of Rice," conducted by a Chinese student, Mr. Y. H. Tong.

The writer understands that the last mentioned work will probably be published by the United States Department of Agriculture.

It is understood, of course, that work done by graduate students is performed by them without expense to the State.

PROPOSED WORK.

As soon as funds are available, the department should have opportunity to lay out an extended series of field plot tests, including such questions as crop rotation and many other crop experiments. These would be very useful in teaching work and would be a source of much interest to visiting farmers as well as a source of scientific information.

The Tompkins County Survey might well be followed by the ownership and management of a farm in the so-called "abandoned farm" section.

An agricultural garden would be of much value to the entire College as well as to the Department of Farm Crops. Such a garden will be developed as rapidly as funds are available. This year 39 varieties of corn were grown in order to get the land in condition for future use.

If one person could give his entire time to co-operative experiments, these could be made of great benefit to the farmers. Probably less attention has been given to such experiments during the past year than during any other recent year.

The studies of pastures and co-operative experiments along this line should be greatly increased.

Probably the greatest returns for the money invested in this department are secured from the survey work. There are two types of this work that should be continued. One is the study of specific crops and the other the study of farming as a business. The pasture experiments and pasture work would include work of the former kind. The Tompkins County Survey is of the latter type.

In the Tompkins County Survey the department has worked out methods so that it is ready for extending the work to other counties. The writer should like to take up the study of a township in one of the farming sections of western New York during the next summer; also a township in St. Lawrence or Jefferson county, and one township between Albany and New York city. These, together with the work which has been done in Tompkins county, would give areas that would represent most of the types of farm conditions in New York.

Among the crop-survey problems which it would be well to take up are the timothy hay question, alfalfa, potatoes, corn.

G. F. WARREN,
Assistant Professor of Farm Crops.

DEPARTMENT OF FARM PRACTICE.

TEACHING WORK.

The number of students in the winter-course in General Agriculture who took the work in Agronomy given by this department was 105, the number of regular and special students who took instruction in farm practice was 10, and there was one student doing graduate work. The winter-course seemed to be more successful than ever before, if the enthusiasm of the students in their work and in the events connected with their stay at the College is an indication of success. The afternoon wörk or practicum, however, suffered much for want of a suitable place in which to conduct it. Some of the time, afternoon sessions were held in the Auditorium, part of the seats being removed to secure space for it. For a few sessions the use of the Farm Corps laboratory was secured.

The work in farm practice is arranged for students who do not come from farms and, therefore, are not familiar with the common farm operations. This instruction was given by the writer's assistant, Mr. E. R. Minns, as successfully as the circumstances would permit. The inherent difficulty of providing suitable work and equipment at such hours as the students have available renders it an open question whether an institution should attempt to provide much such practice work and whether a student should attempt to secure practical experience at an institution while pursuing class-room studies.

In addition to the above the writer has given a few lectures on special crops to the class in Farm Crops.

INVESTIGATION WORK.

The investigations being conducted by this department consist of experiments with fertilizers for mangel-wurzel, comparison of the cost of producing dry matter in crops grown for silage and in root crops, and a study of the durability of roofing materials used on the College farm.

Co-operative experiments have been conducted under the supervision of this department with 75 farmers, and the number of experiments undertaken was 126. These experiments were along the following lines: potatoes, tests of varieties; corn, tests of varieties; soy-

beans, grown in corn for silage; spraying for the destruction of wild mustard; a test of mangels as a substitute for purchased concentrated feeds.

EQUIPMENT.

During the year important additions have been made to the area of farm land available for the use of the College. Much of this area has not yet been taken possession of and the remainder was secured so late in the season that cutting the hay was the only farming attempted on it. The newly acquired area comprises about 380 acres of land, nearly all of which is in a neglected and depleted condition, but when brought into good condition will be of great use to the College. Much of this land, as well as the area previously in our possession, requires draining before it can be satisfactory for use. To facilitate this work, the department has secured a Buckeye Traction Ditcher, which is being used with success.

Extensive additions have been made to the farm machinery equipment.

J. L. STONE,
Professor of Farm Practice.

DEPARTMENT OF EXPERIMENTAL PLANT-BREEDING.

This department was organized in April, 1907, and the experiments have thus been under way but one season, so that little advance has been made.

TEACHING WORK.

The principal work of this department is experimental, and only such graduate students are accepted as are sufficiently advanced in training to conduct investigations under direction. Thirteen such graduate students have pursued investigations in the department during the last year. Problems directly connected with the investigations under way, are assigned to such students, and in this way a much greater amount of work can be accomplished than would otherwise be possible.

INVESTIGATIONS.

Timothy breeding experiments.— New York is a State of diversified agricultural interests, but the hay crop far outranks all others in total acreage and value of product, reaching in 1907, the last year for which reliable figures are available, a total of 4,717,000 acres with a valuation of $91,388,000. Timothy forms far the greater proportion of the hay crop and doubtless greatly exceeds in value that of any other crop grown in the State. Any experiments, therefore, which may lead to the bettering of this crop, are of the greatest importance to the agricultural interests of the State.

Methods of experimentation.— The experiments, which are being conducted on a fairly extensive scale, were started in 1903 by Professors Hunt and Gilmore, then of the Department of Agronomy. The experiments were placed in charge of the Department of Experimental Plant-Breeding in July, 1907. In beginning the experiments, heads of timothy were secured from numerous locations in this and foreign countries, and seed from these was germinated in sterilized soil. The young plants were grown for a time in pots, after which they were planted in the field, being placed in rows three feet apart each way. Of these plants there were originally planted 12,516, the great majority of which are still living.

In 1905, selections were made from these plants of individuals showing various interesting variations, such as heavy yield, light yield,

coarse stems, fine stems, early bloom, late bloom, and the like. Plants grown from open fertilized seed of these various selections were planted in the field in 1905; of these, 147 plats of 32 plants each were grown, making a total of 4,704 plants.

In the summer of 1907, a careful study was made of all of the plants and over 200 selections were made, representing many different types. In the fall of the same year, trial plats were planted from each of these selections and these plats are now showing very interesting developments.

Each year since the beginning of the experiment, records have been made of the height, duration of bloom, season of maturing, yield, etc., of each plant, so that important data is available to serve as a guide in making the selection of the plants which are most likely to prove valuable as foundation stocks of improved races.

The methods of improving timothy have never been worked out, and the first and most important part of the work has thus been to determine the best methods of breeding this crop. Careful studies of the progenies of select plants planted in 1905 have shown conclusively that open-fertilized plants are very variable. It is probable that this great variability is due mainly to the cross-fertilization of different types, or so-called biotypes, many of which are found to exist in timothy. It would thus seem necessary, if different types are to be bred into stable races, that the select plants be inbred or that the progeny be isolated and the results of crossing be slowly weeded out by continuous selection, which would take a number of generations. Experiments which have been recorded in literature up to the present time, indicate that timothy is a strictly cross-fertilized plant and will not set seed by self-fertilization. The writer took charge of these experiments too late in 1907 to make extended experiments to determine this point, as all of the plants were past the regular blooming period. A number of belated heads, however, were inclosed in bags, and practically all of these set some seed, which proved to be of as good vitality and vigor as cross-fertilized seed. Further extended experiments made in the spring and summer of 1908 have shown that self-fertilized seed can be secured from practically all plants but that there is apparently a considerable degree of difference in the capacity of different plants to set seed by self-fertilization. Sufficient seed has been secured in practically all cases for experimental purposes, and the fixation of strains by inbreeding would thus seem to be the practical method of work.

Timothy variations.— Connected with the timothy work, one of the

problems of considerable scientific interest is the study of the variations. Timothy has been cultivated for many years yet practically no attempt has been made to separate out distinct varieties or races. A study of the numerous individuals in our experimental plats shows that very great differentiation has taken place. Numerous individuals can be found exhibiting striking characteristics which are probably to be considered as mutations in the De Vriesian sense, representing elementary species or biotypes. These types are distinguished by difference in height, color, arrangement of leaves, breadth of leaves, size and shape of head and numerous other differentiating characters, and are remarkable for their extent and diversity. A careful study of these variations is being made with the view of determining their true nature. Plats are being grown from self-fertilized seed of over a hundred different types, and in many instances these are being grown in comparison with similar plats planted from open-fertilized seed and from slips or vegetative parts in order to determine the extent of variation under different methods of propagation.

Very extensive data has been accumulated during the experiments, which will give material for a careful statistical study of the range of variation and the preparation of correlation tables. As an illustration of the extent of this data it may be stated that the notes taken for five years annually on over 8,000 plants include weight of product or yield, height, date of beginning of bloom, date of close of bloom, and season of maturing. This study should furnish further information of importance on the nature and range of variation, than which in breeding there is no more important problem. It should show the length of life of timothy and the range of variation in this character which has already been found to be very great. It should determine what variations occur that are important in a superior timothy variety and whether these variations can be perpetuated.

Production of improved varieties.—The studies which have been made of the variations have shown that we have the foundation variations for many important improvements, and would indicate that our agriculture would gain very much by the introduction of special-purpose varieties. The individuals which for the first two years gave the heaviest yields and which for this reason were selected and propagated were in the fourth year, when the writer took charge of the experiments, found to be mainly dead. The individuals which in the third and later years gave the largest yields are all still living. This indicates that there is probably a great difference in the period required by different strains to reach their most productive age, and

would suggest that we should have special quick growing and maturing varieties for short-period rotations, and other varieties for permanent or long-period meadows. We should have early, medium and late varieties in a great hay-producing State like New York, where it is a decided disadvantage to have the entire hay crop mature at the same time. The various individuals differ from three weeks to a month in the period of maturing and there is thus no reason why such varieties should not be secured. Some sorts lodge easily, others are strong-stemmed and never lodge; some plats are very leafy, others nearly leafless; some plants are so constituted that the leaves ripen and dry up before the head is mature and ready to cut, others retain the leaves fresh and green when the heads are normally ripe and ready to cut. All of these important characters are being given careful attention in the breeding work and there is reason to think that improved varieties will result from the experiments which will be of great value.

Rust resistant timothies.— Rust on timothy (*Puccinia graminis*) has in very recent years been rapidly increasing and has now become so abundant that the crop is being severely injured. The disease is widespread over the State, having been found to be common from the extreme north-eastern part of the State to the extreme south-eastern part. It is difficult to place an estimate on the general damage to the crop, but the writer thinks that the crop of the State has been decreased at least 2 per cent. from this source the present season. The impossibility of applying any mechanical treatment for such a disease on a general farm crop such as timothy, renders it imperative that resistant varieties be produced if possible. Fortunately it has been found that a number of the strains under cultivation are to a large extent resistant to the disease and we are thus hopeful that resistant varieties can be produced. Some of the plats from selected plants were this year almost entirely free from the rust while adjoining plats were in many instances so severely injured as to have scarcely shown any growth since the cutting. Such resistant plants put out a vigorous second growth, while adjoining susceptible plats show only here and there a weak isolated sprout.

Corn-breeding experiments.

Practical experiments.— Probably the most important problem in corn-breeding in New York is the production of early races of dent corn, which will be sufficiently early to mature seed in normal seasons and still be vigorous enough to give a good yield of grain and

stover. Selection experiments have been started with three varieties, Pride of the North, Funk's Ninety Day, and Reid's Yellow Dent, located respectively at Aurora, Ballston Lake, and Ithaca. The results this year have been of special interest with reference to the degree of earliness. In each case the plant-to-row method was used and in some progenies at the time of husking practically all of the ears were fully ripe, while in many other progenies almost every ear was yet soft and undented. This great variation in degree of earliness and the proof of the transmission of the character shows, as would be expected, that considerable advance can be made in this direction.

Scientific studies.— It is of great importance in corn-breeding that all characters in any degree correlated with high yield and earliness be discovered in order especially that breeders may be able at the blooming period to recognize probable good yielding and early plants through the correlated characters. If such correlations could be found the breeder would be able more intelligently to select the parents to be mated in pedigreed breeding and could doubtless make much more rapid progress than is now possible.

A statistical study of the most easily recognizable character is being made with two races, Pride of the North and Funk's Ninety Day, with the hope of securing some valuable data of this kind which will be of service to corn-breeders. The information should also be of some value as showing the present range of variation in the various characters of the races used as now grown.

Cereal investigations.

In the breeding and improvement of cereals a co-operation has been arranged with the Bureau of Plant Industry of the United States Department of Agriculture, which will permit the work to be prosecuted on a rather more extensive scale than would otherwise be possible. These experiments started in the spring of 1907.

Oat experiments.— The oat-breeding work is being conducted with two main aims in view. First, to secure better yielding strains, and second, to produce hardy winter oat varieties. In the first instance, the foundation for the work was furnished by the Department of Agriculture placing with the Station seed of a large series of oat hybrids and selections made by Professor Norton in Illinois, together with samples of various standard oat varieties. These are being grown, selected and tested with reference to their adaptability to New York conditions, and their comparative value in connection with standard oat varieties. Some of the strains produce exceptionally

large grains and give promise of value but they will require to be tested through several years before conclusions can be drawn.

The work on the second problem was started in a small way in the fall of 1907, when plats were grown of the Virginia Gray Winter oat from seed grown in Virginia and Connecticut, the seed from the latter State being secured from the selection plats of the Department of Agriculture. Plats were planted on two distinct types of soil, and in each case a considerable percentage of the plants survived the winter, enough to produce at least over half a crop. In an experiment of this kind, nature is the main selecting agent, those plants which survive being considered to be the most hardy. About 300 of the best individuals that survived the winter have been selected for separate planting and general plats will be planted with the remainder of the seed.

Wheat experiments.— In the fall of 1907, 126 varieties of wheat were planted in small test plats and head-to-row plantings were made of select heads of a number of varieties. The first work necessary here is to determine the best foundation stocks by a somewhat careful study of the varieties. The yields in the summer of 1908 have given some indication of the best strains, and a considerable number of individual and head selections of such supposed good strains will be planted in the fall of 1908.

Potato investigations.

Potato-growing is a very important industry in the State and in recent years very little work has been done to keep the varieties up to a high state of productivity. From the great variability of the crop the majority of the varieties grown would seem to be much mixed and lack breeding. It is important that some reliable and simple method of selection or breeding be devised which is adapted to the use of growers generally. Such a method, it is thought, based on the use of the tuber as a unit was devised by the writer in conjunction with Professor Norton and published during the year in Bulletin 251 of this Station. Experiments to test this method more fully were started in a small way in the spring 1908, using several well-known varieties.

The extent of bud-variation in the potato and the use to which the selection of such variations can be put in breeding improved sorts is a question of importance, both from the practical and the scientific standpoint, and some studies of this nature have been started.

Forage-crop investigations.

Some experiments on other forage crops than timothy are being conducted on a small scale. These are as follows:

(1) Experiments with vetch: (a) An investigation of the growing of vetch for seed-production and the production of strains that will give a good crop of seed. (b) An investigation of the methods of breeding vetches by hybridization and selection.

(2) Experiments with clover: Experiments are being made to test variation in the hardiness and productivity of individual clover plants of several species, with the view of conducting careful studies ultimately on this subject. Some forty varieties are being cultivated in small plats.

(3) Experiments with brome-grass: some few selections are under test with the following objects in view: (a) To develop a strain of brome-grass especially adapted for hay and seeding purposes. (b) To develop a strain of brome-grass especially adapted for pasture purposes.

(4) Alfalfa studies: about 30 different strains are being grown to test their comparative adaptability and value as foundation stocks for breeding experiments.

Root-crop investigations.

Some experiments in the breeding of mangels, first started by the Department of Agronomy, were last year placed in charge of this department. These experiments have been conducted primarily to determine the methods of breeding such crops and to determine what could be accomplished in the production of strains giving a high yield of dry matter per acre. The relation of specific gravity to percentage of dry matter has been studied and some interesting data has been secured which it is expected will soon be ready for publication.

Studies of variation.

This line of scientific investigation is being given more attention than any other subject, as it lies at the foundation of all breeding work. It is desirable that we thoroughly understand all types of variation, their cause and use in breeding, and determine whether the breeder can by any means cause or force variations to occur. The investigations under way may be classified primarily under the following heads:

(1) Statistical studies to determine the range of variation and place effects in wild and cultivated plants growing under different condition of natural environment.

(2) Statistical studies of similar plants grown under various artificial environments to determine, if possible, whether variation in any given direction can be increased.

(3) Experiments to determine the value of mutations in plant-breeding.

(4) Experiments to determine the cause and meaning of mutations as distinct from other types of variation.

(5) A study of the mutations of wild plants and their importance in the formation of new types or species in nature.

(6) Experiments to determine whether it is possible by chemical injections or other artificial stimulation applied at certain definite times or continuously, to cause plants to produce mutations or variations of any type of use to the breeder in securing new strains.

Considerable advance has been made on several of these problems and it is expected that several papers will be ready for publication within the next year.

Investigations on the laws of inheritance in hybridization.-

The purpose of these investigations, which are of primary importance in extending our knowledge of the fundamental principles of breeding, is to get further data with reference, (1) to the general application of Mendel's Law of hybrids in different groups of plants; (2) to the relative influence of male and female in the offspring; (3) to the transmission of characters to be expected in hybridization, when nearly related and distantly related parents are used; (4) to the limits of possible hybridization; (5) to the origin of character correlations of the coherital type and their transmission in hybridization, etc.

Investigations of this nature require considerable time as three or four generations of hybrids of known parentage must be grown before safe conclusions can be drawn. Again, in starting the work strains of known origin must be secured of the forms used in the experiments, and this in some cases may require several years of cultivation under controlled conditions. Considerable work of this nature has been started with tomatoes, phlox, verbenas, peppers, poppies and other plants. In work of this nature, plants must be selected which are the best adapted for the particular purpose under consideration, whether or not they are of any practical value. The work of this nature at first requires but little attention, the amount of work greatly increasing as the investigations progress. It is expected that some of the practical experiments outlined above will be completed before the work on these more scientific subjects reach a stage where they will demand any great amount of attention.

Investigation of the cumulative action of selection.

Since the publication of Darwin's classical works, it has been believed that a continuous selection, generation after generation, of the individuals exhibiting a character in the greatest degree, would lead to a gradual augmentation of the character or characters concerned. The policy of the continuous selection of the best has become one of the principles of breeding, universally accepted. The investigations of De Vries on mutations have thrown grave doubt on this principle as the indication from his work is to the effect that the first selection of a striking mutation or sport is the all-important matter, and that following this first selection all that remains to be done is to weed out the effect of crossing and test the comparative value of the new strain by tests with standard sorts. The continuous selection year after year, entails a tremendous amount of careful, painstaking labor on the part of the breeder and if nothing is accomplished by it after the first selection the methods should be changed. This problem, therefore, is one that demands careful investigation, and experiments of this nature have been started, using several varieties of wheat. Here, pure line-breeding is being used, the selections in each case being taken from progeny grown from the same head or spike. The investigation will require to be continued many years to get conclusive evidence; and every effort will be made to make the experiments conclusive and valuable.

Studies on the influence of environment in species and variety formation.

The effect of environment on the evolution of species is still an unsettled question, demanding attention. We need to know from the breeding standpoint, how such changes effect the stability of varieties and species, and whether varieties of a certain type may be better bred under certain environments than under others. This problem is being studied as much as time will permit directly in connection with the investigation of variations. Certain features connected with the problem, such as the possible inheritance of so-called acquired characters, are of special importance and are also receiving some attention.

EXTENSION WORK.

The extension work of this department is expected to be limited. It is necessary, however, that experimenters keep in close touch with the requirements of the State, so that a limited amount of this work can be done without interruption to the experimental work and cer-

tainly, in some instances, to its benefit. The work of this nature done during the year has been as follows:

(1) Lectures on the general subject of plant-breeding have been given before Granges, associations of agriculturists and horticulturists, farmers' institutes and elsewhere. About fifteen such lectures have been given during the year.

(2) Exhibits have been made at the State Fair and the Batavia Fair, representing some of the results secured in the experiments.

(3) An active part was taken in the organization of a New York Plant-Breeders' Association, and such aid was given as possible in furnishing instructions to guide the active breeding work undertaken by the members.

(4) Co-operative breeding experiments with New York crops have been arranged with about twenty-five farmers in various parts of the State, the department arranging and directing the manner in which the work is to be performed.

PUBLICATIONS.

The following publications from the Department of Experimental Plant-Breeding have been issued during the year in the publications of the Experiment Station:

Plant-Breeding for Farmers, by H. J. Webber, Bulletin 251, February, 1908, pp. 289–332.

Testing the Germination of Seed Corn, by M. P. Jones, Circular No. 1, March, 1908, pp. 1–8.

During the ensuing year it is planned to issue bulletins (1) on the timothy experiments, covering studies of variations and life history; (2) statistical studies of variation in various plants, and (3) studies on the relation of specific gravity to dry matter in mangels.

STAFF AND EQUIPMENT.

At the beginning of the year, Mr. J. B. Norton, an investigator of the Department of Agriculture, was appointed Assistant Professor of Plant-Breeding, and continued in the service of this department throughout the year. He resigned at the close of the school year to accept a position again in the Department of Agriculture. Mr. Charles F. Clark, formerly employed in the Department of Agronomy, has been transferred to this department and employed as an instructor.

The following assistants have been employed in connection with the work for the ensuing year: Mr. Fred J. Pritchard, a graduate of

the University of Nebraska and formerly Assistant Professor of Botany in the North Dakota Agricultural College; Mr. Arthur W. Gilbert, a graduate of the Massachusetts Agricultural College and of this University, formerly Assistant Professor of Agronomy of the University of Maine; Mr. Harry H. Love, a graduate of the Illinois Wesleyan University and formerly assistant in plant-breeding in the University of Illinois; Mr. Eugene P. Humbert, a graduate of the Iowa Agricultural College and formerly an instructor in the Department of Farm Crops of that institution.

The equipment of the department is being gradually built up and we are now in fairly good condition for the prosecution of the investigations. A small greenhouse 14 by 50 feet with potting shed has been erected during the year and is a material aid in connection with the work. However, it is far too small to accommodate the needs of the department.

Microscopes, microtomes, chemical apparatus and the like have been secured in sufficient numbers or quantity to meet present demands. A small breeding garden, near the College buildings, organized and run during the past season, has proved a very efficient aid in the investigations.

RECOMMENDATIONS.

The present needs of this department are primarily for greater laboratory space. Already the present quarters are overcrowded and, furthermore, they are poorly adapted to the work in hand. No space is available to accommodate further graduate students and we have been compelled to turn students away who would have been of material aid in extending the investigations. There is no suitable room available for storing material under investigation and this has been a great hindrance to the prosecution of the work. It is earnestly hoped that steps may be taken to remedy this condition in the near future.

A second need of considerable importance is that the areas on the University farm devoted to experimental work be properly fenced. Experiments are under way which have cost thousands of dollars and some of these might be destroyed in a night by a stray animal. The writer considers this an imperative need, which cannot safely be delayed another year.

H. J. WEBBER,
Professor of Experimental Plant-Breeding.

DEPARTMENT OF PLANT PHYSIOLOGY.

Both the teaching and the investigation work in the Department of Plant Physiology began February 1, 1908. This report is, therefore, concerned with the teaching work of one term, and with the work of one growing season, during which time the officers of the department were one professor and one assistant.

TEACHING WORK.

During the second term of the academic year, 1907–8, this department offered two elective courses for undergraduates with suitable preparation, in which courses students were enrolled as follows:

Plant Physiology	15
Crop Ecology	17

In two subdivisions of the work primarily for graduates, the seminar and the research work, the registration was as follows:

Seminar	5
Research students	6

In addition, two graduate students registered in horticulture under the supervision of this department.

In consideration of the number of registrations in undergraduate work, attention should be called to the fact that Plant Physiology is not a prerequisite of any other work in the College of Agriculture, and that, moreover, all students of the College are required to take a course in Animal Physiology or in Human Physiology, and the election of Plant Physiology would be in addition to the parallel required courses mentioned.

Indications are that with the present arrangement, the Department of Plant Physiology will be primarily concerned in its teaching work for a year or two with advanced students. Nevertheless, as shown by the Announcement of Courses for the year 1908–9, an effort has been made to provide a course in physiology which will be of special benefit to agricultural students who expect to return to the farm. The scope of the work given in the session of 1907–8 will be broadened in future as the facilities permit or the demands justify.

INVESTIGATION.

This department receives no federal funds, but it is hoped to make investigations, both fundamental and practical, an important phase of the work. The experimental work thus far undertaken has been in the main preliminary, and many of the lines of work proposed can be made to bear fruitful results only by being continued through several years. Some special lines of work receiving attention may be enumerated as follows:

(a) Observations on environmental factors in relation to the growth of field crops. This line of work involves careful measurements of conditions, both climatological and edaphic, and will include the physiological aspect of certain problems in soil fertility.

(b) A fundamental study of the effects on plants of environmental factors by isolation methods. In this work, experiments have thus far been confined to the laboratory, but special greenhouse conditions will be required in order that the work may have proper scope, and that it may be properly controlled with respect to the factors of growth.

(c) Shade-tent investigations to determine the effects of shading on the minute structure and composition of plants, as well as to determine the practicability of the shade tent in home garden work in the State. The results of the past season have been notably suggestive and material has been secured for careful histological and chemical study.

(d) Stimulation experiments by the use of nonnutrient salts have been conducted on the sweet-pea, the sugar-beet and the radish. Requisite garden space and funds for adequate field experiments were not available during the season just closed, but the experiments were conducted on a scale sufficiently large to give important results which now require only repetition on a more extensive field scale. The experiments have thus far included the effects of metallic salts and halogen compounds. Some positive results have been obtained.

(e) As a phase of the preceding, parallel laboratory experiments have been made to determine exactly the toxic relations of certain crop plants to substances which in dilute form are known to possess stimulating effects with respect to growth processes. This work has awakened considerable interest among some of the advanced students who will now assist by undertaking a special study of some phases of the problem suggested.

(f) Nitrogen fixation by fungi. The study of nitrogen fixation by fungi and its bearing on practical agriculture have been begun, and

this will be made a prominent feature of experimental work of one assistant during 1908–9. In connection with this work, an examination of the effects of commercial preparations of leguminous bacteria has been made, and some methods of preparing the bacteria are being studied.

(g) A problem in enzymatic action has been undertaken, dealing with the organisms required and the conditions favoring the fermentation of tannin in commercial products.

(h) Material has been collected for studies on the cytology of some hybrid agricultural plants.

EXTENSION WORK.

The extension work has necessarily been limited because of the necessity of utilizing a very considerable part of the available funds for equipment. The department, however, has co-operated in every manner possible with the Extension Office, and plans to assist in the preparation of leaflets for the graded schools and for the Farmers' Reading-Course.

STAFF AND EQUIPMENT.

Mr. Lewis Knudson, assistant in the department during the season 1908, has been appointed instructor for the year 1908–9, and the staff has been increased by the appointment for the same year of Mr. M. M. McCool, B. S. A., University of Missouri, as assistant.

During the period which this report covers, the department had temporarily teaching and investigation headquarters in a part of the laboratory of Field Crops. This temporary arrangement prevented the installation of apparatus required and made it difficult to push vigorously the general work of the laboratory. During the late summer, however, a rearrangement of quarters has been effected whereby the Department of Plant Physiology has been transferred to the laboratory space on the first floor of the Agronomy building formerly occupied by the Department of Soils. This must afford for the season 1908–9 satisfactory facilities for the teaching work.

RECOMMENDATIONS.

It is urged that the efficiency of the work in Plant Physiology, and it is believed that the efficiency of the work in plant industry generally, would be greatly enhanced by the establishment and maintenance, as soon as possible, of a plant industry garden. The special experimental plots of the diverse departments seem only to fill special

needs and some general garden conjointly administered would unquestionably afford valuable material for a large number of departments, and would permit of the ready investigation of many problems which may not now be undertaken owing to the impossiblity of securing material at the time desired.

The most urgent special need of the Department of Plant Physiology is greenhouse facilities, and it is hoped that this will be met by the plans of greenhouse construction now being developed. Ground for field experiments is also greatly needed, although the department makes use of the growing crops planted for general supply purposes.

Owing to the great demand for books along botanical lines by departments widely separated, it is suggested that the development of the agricultural library with sufficient force to keep the library open during the hours when the University library is open, will greatly facilitiate the student and departmental work.

B. M. DUGGAR,
Professor of Plant Physiology.

DEPARTMENT OF PLANT PATHOLOGY.

TEACHING WORK.

During the last year, two University courses were offered in Plant Pathology, the beginning, half-year course and the advanced full-year course. There were about 35 students registered in the beginning course and 6 in the advanced course. Because of the torn-up condition of the laboratories and the necessity of conducting this work while the workmen were remodeling the rooms, much of the work was not very satisfactory. However, the increase in the number of students was gratifying. The teaching work necessarily engaged a considerable part of the writer's time as well as that of Mr. Reddick during the winter months.

INVESTIGATION.

The research work during the past year was continued along several lines begun previously.

The grape-disease investigation, in charge of Mr. Reddick, was conducted in a manner very similar to that of last year. The laboratory established the year before was changed from the Lansing to the Cushman vineyards, near Romulus. The work was done, as last year, in co-operation with Professor Wilson of the Department of Horticulture. Mr. Reddick was on the ground throughout the season from early in June until the middle of October. He has prepared a brief statement in regard to this work, as follows:

"The black-rot of grape investigation was continued this year according to the general plan laid down at the beginning of the work. The field laboratory at Romulus, N. Y., was maintained during the entire summer, but was moved to a vineyard which was practically abandoned. This afforded better opportunity for a study of the disease-producing organism. In many sections of the vineyard the losses were total. The very frequent heavy local rains which continued until nearly the middle of August afforded abundant opportunity for infection, and much valuable data regarding dissemination, infection, etc., were obtained. Some problems left from last year still remain unsolved. In co-operation with the Department of Horti-

culture a spraying experiment was conducted to demonstrate the method of control of this disease. There were seven acres of vines in the experimental plat, each acre receiving different treatment. One acre was left untouched and saved as a check. The results of spraying with various strengths of Bordeaux mixture were very apparent to the eye and the results will doubtless be very striking.

"The importance of being on the ground was demonstrated in numerous instances both in the technical and practical work. The meteorological conditions are peculiar to the immediate vicinity and can be determined only by being on the ground and studying them.

"Incident to the black-rot investigation, opportunity was afforded to follow through the season another disease which is proving destructive in all the grape-growing regions of the State. The organism causing the disease has been isolated and some points in the life history determined; also an apparent means of control seems to have been discovered."

Bean-disease investigation was put under the direct charge of Mr. M. F. Barrus, assistant in the department for the coming year. By co-operative arrangement, the department was able to establish a field laboratory on the farms of the Burt Olney Canning Co., Oneida, N. Y. Here, beginning the first of July and extending until the latter part of August, Mr. Barrus continued the investigations made in this department for the past three years in the study of bean anthracnose and other diseases of the bean crop. Mr. Barrus had full charge of the spraying operations on the farms of the company, the main object of his work being to determine whether spraying beans as generally practiced on these farms was profitable or not. Because of the very dry season, there was relatively little anthracnose. The general conclusion reached is that spraying beans with Bordeaux mixture in seasons even when there is no anthracnose may slightly increase the yield, but not sufficiently to make it profitable.

Mr. Barrus also made studies on the bacterial blight and on the new stem disease of beans, which causes the top to break over at about blossoming time. The work will be continued on these farms during the next two or three years.

Black-rot of gladiolas.—Mr. E. Wallace, a graduate student in the department has been conducting during the past year, investigations on the bulb-rot of gladiolas. This bulb-rot seems to be the most serious disease that gladiola-growers have to contend with. Losses from this disease alone reach in some cases as much as $8,000 annually. It is hoped that the work on the bulb-rot will be completed

by spring. A large number of experiments in the storing of the bulbs are now under way, to determine what relation the storage may bear to the development and severity of the disease.

Apple-scab fungus.— Mr. Wallace has also been conducting investigations of the apple-scab fungus, and has worked out fully most of the points in the life history of this parasite, having added considerable to our knowledge of the development and dissemination of the winter spores. It is planned to continue this work for several years, taking up the practical and economic phases of the disease as well as the spread of the scab in storage; late infection of the fruits, which have in certain sections of the State been marked this year; secondary infection by other fungi through the scab spots, etc.

Hollyhock diseases.—An extensive experiment in the control of the diseases of hollyhocks, particularly the rust, was undertaken this spring. Mr. Taubenhaus, a graduate student in the department, had direct charge of the work. Some 130 varieties of hollyhocks were planted on the grounds of the University farm, on which experiments with various colorless sprays were performed. Over two thousand hollyhock plants were included in the experiment, and seven different spray mixtures were tried. The plants were started in the greenhouse and planted out this spring. Relatively little rust appeared during the present season, so that no conclusions could be drawn in regard to its control. However, anthracnose was very severe on all of the plats. Bordeaux mixture which was used on one of the plats as a check against the other mixtures, showed the most efficiency in the control of the anthracnose, while the other mixtures were effective in the following order:

Lime sulfur, Niagara brand, 1 part in 20 of water.
Copper sulfate, 1½% solution.
Ordinary ammoniacal copper carbonate.
Soda Bordeaux.
Sulfuric acid.
Potassium sulfid.

It is intended to continue this experiment another season at least in order to check up the results of the past season and to determine the effect of these spray mixtures on the rust which is beginning to appear in great abundance late this season, after the spraying has ceased.

Peach leaf-curl.— Early last spring a circular letter was addressed to many of the peach-growers throughout the State asking for information in regard to the amount of curl that had occurred on the

peach trees in their section, the methods employed for controlling it and the success of such methods. A large number of replies were received, owing to the fact that this was an especially favorable season for the development of the curl, and it is expected that the tabulation of these replies will show interesting facts in regard to the general practice of peach-growers in controlling this disease, and also as to the results that may be expected in the years when the disease is especially severe. It is planned to tabulate the results, and to present them in the form of a short bulletin some time this winter or early spring.

Fire-blight in nurseries.— During the past year, some observations have been made and field work done in co-operation with a nursery company in the control of fire blight in the nursery stock. The apparent increase in the amount of blight on apples throughout the State seems to have extended to the nursery, and the losses in many nurseries this year were very heavy. However, in the nurseries in which the co-operative experiments were being conducted there was relatively little loss this year, although the disease appeared as usual in many of the blocks. The recommendations for the control of the disease in nursery stock were to locate and cut out all old trees or parts of trees harboring the disease in cankers and blight cankers, and the careful and systematic cutting out of the blight in the young trees throughout the season. The work was performed by the nurserymen under the general direction of this department. The work seems to have been done effectively, for while other nurseries not far away suffered from the disease, there was relatively little loss in the one under the control of this department.

The plant-disease survey work was continued in co-operation with the United States Department of Agriculture. The increase in the correspondence has been very marked. Many circular letters regarding plant diseases were sent to growers all over the State, and the replies, together with the reports of the regular plant-disease reporters in different sections, give evidence of the general interest among growers in plant-disease matters. It is expected to continue this work and to enlarge it next year, as it is thought that in this way the department can get at many important facts regarding the general practices and the amount of loss from different diseases.

EXTENSION WORK.

The extension work during the past year has been a continuation of that begun last year. Much of the correspondence of the depart-

ment is in the nature of extension work; in fact, most of it may be properly considered as coming under this head, as it consists in answering inquiries regarding the diseases of crops. The increase in this kind of correspondence has been gratifying, as the writer feels that this is evidence that the people of the State are becoming acquainted with the department and have confidence in the work that it is doing. The writer has made it a point always to answer questions of this sort with care and dispatch, although, owing to the lack of assistance, important matters have frequently been much delayed. In connection with this work, there is much need of a laboratory assistant who can give practically all of his time to the work of determining diseases sent in, and to getting the information necessary for intelligent answers. The correspondence during the past summer approximated during some months, as much as 200 letters per week.

Much of the increased correspondence and interest in the work, the writer thinks, is due largely to the exhibits that have been made for the past three years at the State and county fairs. During the past year, plant-disease exhibits were made at the State Fair and four county fairs, namely the Union Fair at Trumansburg, the Chautauqua Fair at Fredonia, the Genesee Fair at Batavia, the Steuben Fair at Bath. The work that the department has been able to do at these fairs has been so gratifying that it has established it as a fixed practice in the extension work, and has this year begun to put the exhibit in permanent form, having learned during the past three years about what will best accomplish the purpose and in what condition it can best be transported.

The value of this extension work seems to be mainly along the following lines: (1) That it puts the department in touch with a much larger number of people of the State than it could otherwise hope to meet by individual traveling or to become acquainted with through correspondence. (2) By bringing to the people of any section concrete and living examples of the diseases with which they in particular are troubled, the department is enabled to enlist their attention and interest more efficiently. To see on the table before him as he passes before the exhibit, scabby pears, identical in appearance with what he has at home, or alfalfa entwined with the so-much-dreaded dodder which he has seen in his neighbor's field, the grower cannot help but stop to examine and inquire. It has been made a practice at the fairs this year to pass out to any interested person a card bearing the names of the staff of the department and indicating the particular line to which each man is devoting his time.

It is hoped that these cards will serve as reminders to the men who take them that there is a place in the State where they can look for assistance in controlling the diseases which give them trouble. That this is an efficient means of increasing the correspondence is shown by the fact that the cards are returned frequently throughout the year accompanied by inquiries for information on certain diseases.

Further, this sort of extension work is most effective since it brings the department in personal contact with the man whom it is its business to assist. To be able to talk the matter over with the man, to get his point of view, and to see what the conditions are in his particular case, are much more helpful in the final solution of the problem than even the most extended correspondence can be expected to be. The department should like as soon as sufficient funds and assistants are at hand, to attend all of the important county fairs in the State each year.

Another kind of extension work that the department has been doing is the attending of farmers' meetings of various kinds, particularly local Granges and farmers' clubs and societies. A considerable part of these meetings have been attended during the past summer, and talks and discussions given on plant-disease work.

ADDITIONS TO THE STAFF AND EQUIPMENT.

During the past year Mr. Donald Reddick, who last year began the work on the black-rot of grapes, was made assistant in the department. He has devoted the major part of his time to the investigation work on the black-rot of grapes, a report of which is included above. A small part of his time during the latter part of the winter was devoted to teaching advanced students. Mr. Reddick has been made Instructor for the coming year, and will continue his work on the black-rot in the hope that it may be completed and be put in bulletin form by the end of the year.

During the Easter vacation, the changes and improvements in the quarters of the department were finally completed, and although the department had been occupying the rooms during the entire winter, it was not until this time that it was finally able to organize its equipment. The beginning course in Plant Pathology, through the kindness of the Horticultural Department, had been given in one of their laboratories. This work was transferred to the department's own quarters at Easter vacation. During the summer, considerable time has been devoted to putting the quarters into condition for the work of the year. Much yet remains to be done. The equipment,

as a whole, is satisfactory and nearly complete, and is perhaps as large and efficient as any equipment of its kind in the country. However, the increase in the number of students taking the work, which has been about 25% this year, taxes the present equipment to its full extent. Any increase another year will demand more equipment. Particularly will desks and microscopes, with room to place them, be needed.

RECOMMENDATIONS.

The writer recommends an increase in the number of assistants to accomplish the details of the work now in hand. During the past year there has been only one assistant, and as his time was devoted very largely to research work, there has been practically no help of any kind to keep the laboratory in condition, and to do the ordinary laboratory work, which is considerable. The necessity for more help is urgent.

Next to the need for more help is the need for more room. The new quarters have been filled during the past year, and the indications are that there will not be room to house all of the students who desire to take the work next year. The only alternative will be to turn away students.

The results of the past year's work have been fully up to the prospects anticipated in last year's report, and the Department of Plant Pathology looks forward to another year of work and progress with much pleasure.

H. H. WHETZEL,
Assistant Professor of Plant Pathology.

DEPARTMENT OF SOILS.

TEACHING WORK.

During the college year covered by this report there were 166 registrations for instruction, representing 141 persons, some individuals having registered in more than one course. The department offers seven distinct courses of instruction, two of which are elementary and are intended, the one for the regular four-year students who have had full preparation in the natural sciences, the other for one- or two-year specials who, because of lack of time or other reasons, prefer a less advanced treatment of the subject. Of the total registration, 103 were in these courses, which are prerequisite to admission to the more advanced courses which deal with particular phases of the subject in its various practical and scientific relations. These courses may be grouped in two divisions, the one designed for those persons who are interested in the purely practical application and desire to secure definite informational facts, the other for those students who contemplate specialization along soils lines and desire to prepare for research work or advanced teaching work. In this latter case the courses are designed to lead up to and give some practice in independent investigation. Of the remaining 63 registrations in the department, 34 were in the first division and 29 in the latter division. This embraced 10 students pursuing graduate work.

RESEARCH WORK.

The department is conducting investigation into several problems of fundamental importance in soil management, notable of which are (1) the principles of soil granulation and (2) some phases in the movement of soil moisture. Considerable data have been accumulated along these lines.

EXTENSION WORK.

The extension work has been the most prominent form of activity of the department outside of University teaching. This has been in four parts, viz.: (1) Teaching and correspondence, (2) surveys, (3) experimentation, and (4) publication.

(1) *Teaching.* About a dozen addresses were given before audiences

of farmers either at the college or out in the State in agricultural gatherings. This work has been kept distinctly secondary because it greatly interferes with regular University teaching.

Exhibits of an educational character were made at the State fair and at the Genesee county fair, at both of which special emphasis was put on the need and effects of better soil drainage through the State.

A large part of the correspondence of the department is of an extension character in that it is the answering of inquiries concerning soil problems. These aggregated several hundred letters during the year.

(2) *Survey*. The department feels that the prerequisite to intelligent soil investigation on the farms of the State is a knowledge of the general soil conditions as they can be determined by field examination. Not only is the distribution of different soil conditions determined but much information concerning the relation of these soils to crop and farm conditions is secured by such methods, which are absolutely essential to a proper prosecution of practically all other phases of farm and orchard investigation. The relation is even more far-reaching than first thought might indicate. And it is the beginning point and prominent basis for understanding of the so-called "abandoned farm" problem of the State. Therefore, a large part of the extension funds available to the department have been used in this direction. And since the soil distribution and classification is not limited by State lines but is a part of the national domain, and because not only could greater uniformity in method be attained but also because more work for the State could be accomplished, these funds have been expended in co-operation with the Bureau of Soils of the United States Department of Agriculture, such arrangement having been made with the Secretary of Agriculture and the Chief of the Bureau of Soils through the director's office and direction. By this arrangement, the College of Agriculture furnishes a man for each man supplied by the Bureau and meets one-half of the field expenses of the party. The selection of areas to be surveyed is largely at the suggestion of the College, and while the reports and maps on such areas surveyed are published by the Bureau, they are also available for publication by this College.

During the past season, beginning July 1st, soil surveys on a scale of one inch equal to one mile were in progress in Livingston and Montgomery counties, which have an aggregate area of 1,043 square miles. The College maintained two men in the former area and one in the latter, and on September 30th there had been mapped ap-

proximately 496 square miles in the former area and 284 square miles in the latter area. The completion of this work and the preparation of the reports will run into the next fiscal year.

(3) *Experimental.* Under the head of co-operative experiments, a number of farmers in the State have undertaken work with fertilizers and methods of tillage. About 18 men have taken up work at the suggestion of the College.

A more close type of co-operative experimentation was taken up within the year with Mr. W. B. Howland, of Orange county, New York, who owns a farm, a large part of which is muck soil, on which he desires to grow onions. Because there are large areas of such soil in the State similarly situated, from which the question of fertilizer requirements for the best and most economical growth of certain crops arises, it seemed best to establish an extensive series of fertilizer experiments. The work is under the immediate supervision of this department. It consists of 54 one-tenth-acre plots on which onions are grown. It is expected to continue the study for five years, when the data may be published. Although the season has been very adverse, some very interesting results have been obtained.

(4) *Publications.* A bulletin of 40 pages, dealing with Drainage in New York State, was published in May.

EQUIPMENT.

Owing to the occupancy of the new agricultural buildings within the year, the laboratory facilities of the department have been much extended and many new pieces of apparatus for the study of soils have been installed.

ENLARGEMENT OF THE WORK.

There are many lines along which the work of the department may be expanded and improved when funds are available. In the teaching work, a new course in Irrigation and Drainage should be given, with facilities for demonstration and laboratory study. Some work along these lines is now given in the regular courses. The proposed new greenhouses will meet these needs only in part.

A number of pieces of apparatus are needed in the laboratories to make them entirely adequate for the needs of student work, and there is much illustrative material, the accession of which would materially strengthen the teaching in the department.

On the extension side, there is even greater need for more work. The soil survey should be pushed to completion with increased rapidity, and with it other lines of investigation should be taken up.

Three primary lines, aside from the survey, are urged for consideration as soon as funds for them shall be available:

(a) *Drainage.* A study of the drainage properties of the different soil types and of the best methods of removing the water from each, together with a study of the effectiveness and durability of different types of tile under different conditions of soil and climate.

(b) *Fertilizer needs of soil.* The department receives many inquiries from farmers for information as to the best fertilizers for their uses. While some facts bearing on the mode of action of fertilizers are still lacking in soil knowledge, it is entirely feasable to gain practical information about the fertilizer needs of different soils by field-plot investigation, and it is felt that such information should be obtained on a number of points on the important soil formations of the State. The special study of the effects of lime is one phase of the problem; that of the humus supply is another. Sooner or later such work must be done.

(c) *Soil management.* The writer wishes to repeat the suggestions made in other connections, of the great desirability of the College securing a farm unit area of the typical hill land of the southern part of the State for study and demonstration of the possibilities of managing and improving in a practical way this extensive area of soil. It brings to the College some of the most difficult problems. Its solution does not lay in the domain of any single department. The soil conditions are one fundamental factor. In the opinion of the writer, only by combining these various factors into a business experiment can the maximum of value for the farmer of the present generation be secured. Such a farm of proper area — the writer would suggest at least 250 acres — should be typically located and should be conducted for 10 years as a business experiment.

E. O. FIPPIN,

Assistant Professor of Soils.

DEPARTMENT OF SOIL INVESTIGATIONS.

Status of the Department.

In accordance with the writer's understanding of the nature of the work for the prosecution of which this department was created, it has been equipped and its experiments planned with the purpose of conducting investigations of the principles underlying those properties of the soil that affect its productiveness. While, in the course of these investigations, some results will be obtained that will be of immediate benefit to farmers and others who are engaged in growing crops, the larger part of the returns will contribute to that knowledge of the properties of soils and their relation to plant growth, the possession of which is necessary for the intelligent conduct of the more immediately practical experimentation.

That the time has come when the continuing and increasing usefulness of the experiment stations throughout the country is dependent on work of this nature in certain lines of experimentation, is evidenced by the passage by Congress of the Hatch Act, providing expressly and exclusively for fundamental research. It is in the spirit of this act that the work of this department is being prosecuted.

Teaching Work.

Training is given in this department only to graduate students who are qualified to assist in the investigations, and who are willing to give sufficient time to the work to follow with thoroughness some line of experimentation. Registration is thus confined to students taking their major subjects in this laboratory, and with one exception to candidates for the degree of Doctor of Philosophy. During the past year five students have received training in this laboratory, being graduates of the following colleges:

Purdue University, University of Illinois, Agricultural College of North Carolina, Virginia Polytechnic Institute, Iowa Agricultural College.

A limited number of well-qualified students are an aid to the work, and take the place of men who, in the absence of student help, would have to be well paid. Assistance of this kind, however, has the disadvantage of requiring considerable time and attention from the in-

vestigator, and as students are a transient class, new men must be taken on and trained at inconveniently short periods. The proper numerical balance between the permanent staff and the student corps is yet to be determined.

INVESTIGATION WORK.

The investigations of the department are conducted in (1) the experiment field on the University Farm, (2) in a small glass-house, and (3) in the laboratory. Experiments will soon be begun in the soil tanks which will shortly be completed on the experiment field.

It is intended to limit the number of distinct lines of investigations to a small number. This will permit of a better development of any one subject, which must always be subdivided into a considerable number of separate investigations, and the more of these that can be conducted at one time the sooner definite conclusions can be reached. The natural limit to a concentration of effort, in this way, arises from the slowness with which results come from experimentation that involves the growth of crops. As one step leads to another in experimentation, it is necessary to finish certain sub-investigations before beginning others; hence, in spite of the desirability for concentration, the time of the staff can be more economically spent on three or four lines of work than on one.

The main lines of investigations, together with the subdivisions now being conducted, are as follows:

(1) Effect of moisture and temperature on the availability and utilization of plant nutrients in the soil, and the relation of this to crop production. Including

(a) Relation between soil-moisture content and the removal of nutrients by the plant.

(b) Relation between soil temperature and the removal of nutrients by the plant.

(c) Relation between the removal of certain nutrients by the plant and the yield and composition of the plant.

(d) Relation between the moisture content of the soil and transpiration by the plant, and between the transpiration and the absorption of nutrients.

(e) Effect of moisture content on root growth.

(f) Effect of moisture content on bacterial flora.

(g) Conditions affecting the concentration and composition of the soil-water solution.

(h) Relation between the concentration of the soil-water solution, and the absorption of nutrients by the plant.

(i) Effect of application of certain fertilizers on the density of the soil-water solution.

(j) Influence of absorption by the soil particles on the removal by plants of salts from the soil-water solution.

(2) Influence of certain atmospheric conditions on the absorption of mineral nutrients by plants. Including

(a) Relation of transpiration to atmospheric humidity, temperature and intensity of sunlight.

(b) Relation between transpiration, under these conditions, and the acquisition of nutrients from the soil.

(3) A study of certain unproductive soil with special reference to the activities of its bacterial flora.

(a) Effect of sterilization with steam, and with volatile antiseptics on the soil in question, as well as upon others.

(a) Effect on crop production.

(b) Effect on physiological activities of ammonifying and nitrifying bacteria.

(c) Effect on the relative number and activity of aerobic and anaerobic forms.

(d) Inoculation of sterilized and unsterilized good soil with infusions of sterilized and unsterilized poor soil.

(e) Inoculation of sterilized poor soil, and of good soil, with cultures of bacteria peculiar to or occurring in large numbers in the poor soil.

(b) Effect of aeration on the bacterial processes in these soils, the immediate effect of sterilization being to make the poor soil more productive than the good.

(a) An enumeration of the aerobic and anaerobic forms in the aerated and unaerated soils.

(b) Inoculation with cultures of the predominating forms of bacteria from the unaerated soils.

(c) Determination of the oxygen absorptive powers of the soils, and production of carbon dioxid.

(4) The character and concentration of the aqueous extract of a soil under different methods of treatment.

(a) Extractions are being made of the soils on the various plats occupied by the experiments in which timothy hay is being grown under different methods of fertilization and in a rotation including corn, oats and wheat. Determinations of nitrates are being made

in these soils to show the effect of (1) nitrate fertilizers, (2) fertilizers not containing nitrogen, (3) farm manure, (4) lime, on the soil extract when each of the crops mentioned is growing on the soil. A space of twenty-five feet at the end of each plat is kept free from any vegetation in order to ascertain the effect on the soil when no crop is present to absorb nitrates.

(b) Similar determinations are being made on corn land having plats treated as follows: (1) cultivated, (2) mulched, (3) uncultivated but weeds removed by scraping, (4) weeds allowed to grow, (5) fertilized.

(c) The effect of complete and partial sterilization as described under (1) and (2) on the soil extract, is being determined.

(d) The production of plants and roots grown in the extracts of the soils treated as already described.

Tanks for soil investigation.— These tanks are now nearly completed. They are intended to furnish receptacles for bodies of soil of sufficient size to produce plants in a normal manner under approximately field conditions, and yet afford opportunity for measuring a large number of the factors affecting plant-growth. The construction is of concrete, but the tanks will be lined.

Each tank is four feet two inches square with a maximum vertical depth of four feet six inches and a minimum depth of four feet. There are twenty-four tanks placed in two rows of twelve tanks each. Between the rows of tanks is a tunnel the bottom of which is ten feet below the top of the tanks. The tunnel is six feet wide. From the lowest point in each tank is an outlet tube two inches in diameter and tin lined. It is made large enough to permit of easy cleaning and has no bends in it. A piston runs through the tube to within four inches of the upper end. Between the perforated head of the piston and the soil, glass wool is to be inserted. The piston can be withdrawn if it is desired to clean the tube. Drainage water from each tank will be caught in a receptacle in the tunnel. The lining in the tanks will prevent any soluble material in the concrete from appearing in the drainage water. A constant water-table at any desired depth may be maintained by raising the rubber tube leading from the outlet tube to a corresponding point below the surface of the soil in the tank.

The tanks as described will each contain between three and four tons of soil, and the surface will constitute .0004 of an acre. They are built with special reference to durability so that it will be possible to plan for experiments to extend over a long period. The quantity of soil contained is not too large to allow of accuracy in sampling and yet is sufficiently

large closely to resemble field conditions, which is not true of the quantity contained in pots. No covering is to be placed over the tanks, but in every way natural conditions are to be permitted. The top soil and subsoil will be placed in their relative positions. It is expected that the rainfall will be sufficient to meet the needs of the crops, but if the plants suffer during periods of drought they can be watered artificially.

Any desired type of soil may be used, which is not possible with ordinary field experiments. It is also possible to make a comparison of different soil types under any desired condition, which may be very serviceable in ascertaining the effect of those properties differentiating these types upon certain factors in soil productiveness.

The chief feature of the plan is that of keeping accurate records of the factors affecting plant-growth without producing artificial conditions.

The tube leading from the bottom of the tank is designed to carry off the drainage water into a receptacle which will permit the quantity to be measured and its constituents to be determined. This will permit of an estimation of the amount of moisture used by the crop, and will make it possible to trace more closely the disposition of plant-food.

The accompanying diagram shows the plan and cross-section of these tanks.

There are certain experiments involving fundamental problems in soil productiveness that can be conducted only where it is possible to control and measure the conditions affecting plant growth, and maintain the experiments through a long period of years, as is the case with these soil tanks. Some of these problems are as follows:

Effect of the continuous use of large amounts of mineral fetilizers on the physical and chemical properties of the soil and on the bacterial flora and bacterial activity.

The conditions under which lime is lost in the drainage water.

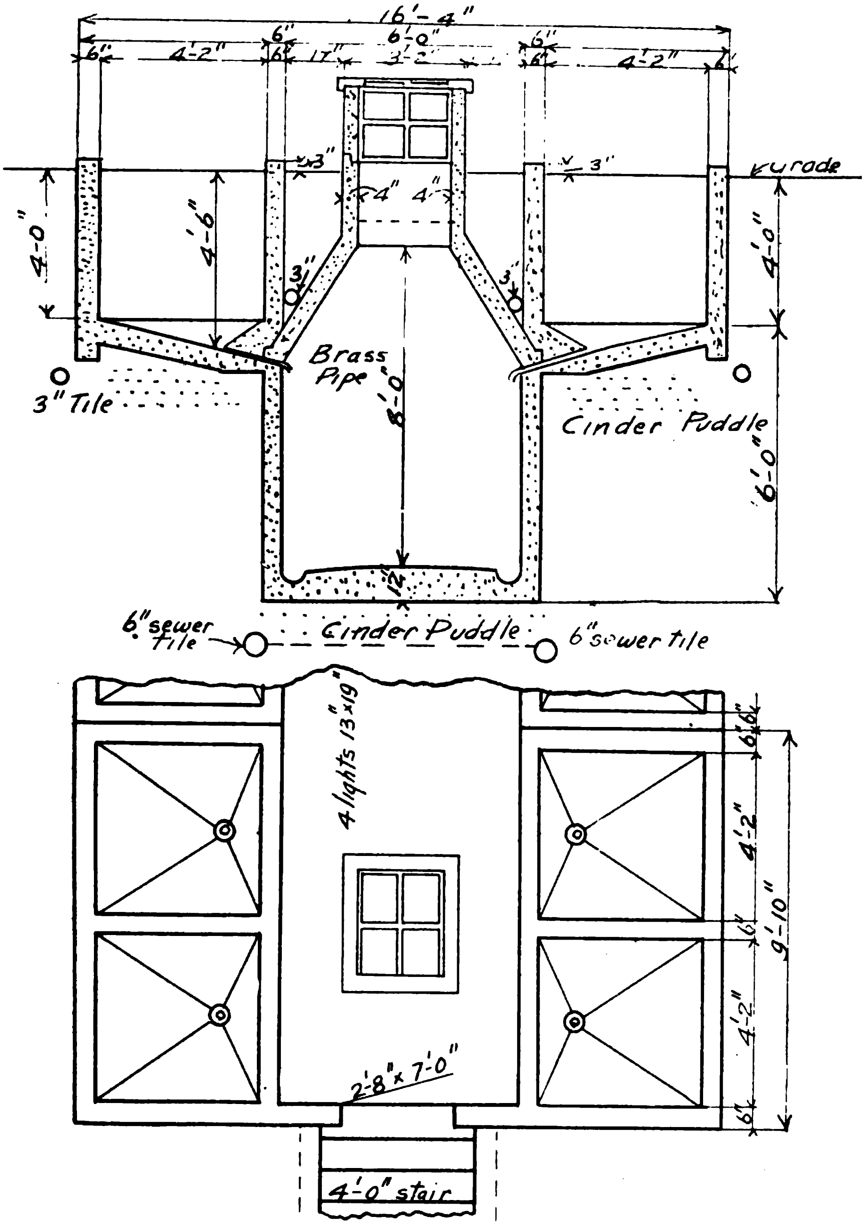
Changes that occur in a series of years when soils gradually deteriorate or improve.

Extent to which soils under field conditions are renewed by accession of lower soil to the plowed part through the wearing away of the top soil.

Effect of certain crops on the permeability and certain other physical properties of the soil, and on the loss of plant nutrients.

The loss of potassium and other substances occasioned by manuring with lime.

Loss of plant nutrients caused by clean cultivation.



TANKS FOR
SOIL INVESTIGATION
CORNELL UNIVERSITY
Scale $\frac{1}{4}$" = 1'-0"

RECOMMENDATIONS.

It is very desirable that the experiment field should be enclosed by a tight fence. At present, three sides of the field are not protected, and the fence between this field and the pasture on the north is a poor one. Last summer the steers in the pasture broke into the experiment field and seriously injured the experiments. Experiments conducted under such conditions can never furnish results that are trustworthy, and an entire year's work is likely to be lost at any time.

Wagon scales at the experiment field would save a great deal of hauling and save much expense thereby. Everything weighed in a wagon must now be hauled to the north barn, nearly a mile away. Wagon scales would pay for themselves in a short time. The writer hopes that it may be possible to partition off a small part of the soils research laboratory for that part of the bacteriological work that requires the absence of dust. A room about eight feet square, similar to the one in the dairy laboratory would suffice. The chemical and other work in the laboratory makes certain of the bacteriological work very unsatisfactory at present.

T. L. LYON,

Professor of Soil Investigations.

DEPARTMENT OF HORTICULTURE.

The past year has been marked by important material advancement. The new offices, class-rooms and laboratories occupying the second floor of the main building have been equipped with furniture and apparatus. The increased facilities have greatly augmented the efficiency of our service. A beginning on much-needed greenhouse equipment was made by the passage of an appropriation for the erection of glasshouses. The floricultural interests of the state are enormous. Thus far they have not received adequate consideration at our hands. The new houses, although insufficient for our needs, will when completed enable us to take up pressing problems in the culture of forcing crops and co-operate with commercial florists in an effective way.

Another important addition to the material equipment of the department is the securing of fifty acres of land to be used for the growing of pomological products. This will serve as a field laboratory for instruction and an area for experimenting. The land is being prepared for tree occupancy, and plans are being made for planting and experimental work.

OLERICULTURE AND FLORICULTURE.

The truck farm survey of Long Island was prosecuted for about a month this summer, having been begun a year ago. This, so far as known, is the first systematic survey of vegetable-growing to be undertaken by any experiment station, and the data now accumulating promise to be of great interest and value to the men engaged in this industry. Long Island is, perhaps, the most favored region in the State for trucking, for in addition to its proximity to the best of markets it has a longer growing season and milder winter than any other region, and a light, sandy soil that responds immediately to fertilizers, can be worked wet or dry, and is very early. The leading truckers for the most part are very progressive men, and handle all departments of the business with skill; but many of the rank and file are still backward, and might be greatly benefited by such a report as is contemplated.

Thousands of acres in the interior of the island, now producing nothing but scrubby growths of pine, oak and chestnut, are well adapted to vegetables, as has been shown clearly by the experimental farms of the Long Island railroad at Wading river and Medford; and it is hoped to show in the report that great opportunities here await the farmer of small means.

The information gathered concerns soils, crops, methods, labor, harvesting, marketing, and the like. Only one man has worked on the survey

so far, and he only for a few weeks, so much remains to be done; but with a small corps of assistants, such as is hoped will be available another season, at least enough territory will be covered to warrant issuing a printed report.

Several meetings were addressed during the past year, among them Grange meetings at North LeRoy and Batavia, an Institute at Jefferson, and a Farmers' Club at Versailles.

A plot of about one and one-half acres of sandy land just south of the astronomical observatory has been set aside for vegetable-growing, and on this some fifty varieties of vegetables were tested this season, and experiments begun with asparagus. On this ground, also, the practical work in olericulture is given to the students.

Plans for the new greenhouses were prepared during the summer and submitted to the State Architect. With the increased facilities these houses will afford for floriculture and vegetable forcing it is proposed to push the development of these subjects rapidly.

L. B. JUDSON,
Olericulture and Floriculture.

POMOLOGY.

Investigation.

Black-rot of the grape.— An eight-acre plat was chosen in the vineyard of Mr. Cushman at Romulus. The plat was sprayed with mixtures differing in composition, strength and the number of applications. The results show that the disease may be controlled by the use of fungicides.

Peach yellows.— An inspection of peach yellows and little peach was conducted during the summer in the orchards of the Youngstown district, Niagara county. The purpose of this experiment was to determine the value of the extermination method as a means of control. The experiment was a concentration of a previous year's investigation conducted in co-operation with the United States Department of Agriculture. Two inspections were made, the first August 1st to 15th, the second September 1st to 17th.

Orchard management.—An orchard-management experiment was instituted in the orchard of Mr. Judson Knapp at Syracuse. The orchard is nineteen years old and does not bear. The purpose of the experiment was to determine the cause of the barrenness. It is being pursued in co-operation with the Department of Entomology.

Extension work.

Orchard surveys.— The county of Orange was finished last June. Ontario county was surveyed during June, July and August. The field work was done by A. W. McKay, assisted by W. A. Salisbury. Over eight hundred different orchards were surveyed. Monroe county was surveyed during June, July and August. The field work was done by

Messrs. Burritt, Alderman and Anderson. About nine hundred orchards were surveyed.

During the college year and the summer vacation, several addresses were given at fruit meetings in various parts of the State.

C. S. WILSON,
Pomology.

PUBLICATIONS AND OTHER INVESTIGATIONS.

Peonies.— The studies commenced on the peony in co-operation with the American Peony Society four years ago have been continued. A check list containing the names and citations of some two thousand references was published as a preliminary step, and this has been followed by a bulletin describing the leading varieties. This work has been done under the writer's direction, first by Mr. J. E. Coit and later by Mr. L. D. Batchelor.

Beans.— A varietal and monographic study of beans has been in progress in the Department of Horticulture for several years. An important step in the work is marked by the preparation for publication, by Mr. C. D. Jarvis, of a monograph which classifies and describes practically all varieties of cultivated garden beans.

Black-rot of the grape.— A bulletin on this important question, prepared by Professor Wilson and Mr. Reddick and giving the results of experiments of black-rot, was published.

The department also assisted in the preparation of a bulletin giving general direction for the prevention of plant diseases and injurious insects.

SURVEYS OF NEW YORK ORCHARDS.

It seems opportune at this time to present something in the nature of a historical statement regarding the development of the Cornell orchard survey movement. It is also proper to explain that the orchard survey as at present conducted combines the features of a census and those of a biological study. In this it differs radically from anything of the kind previously attempted. It is also proper to say that the present orchard examination was foreshadowed by the series of extension bulletins on orcharding in Western New York prepared by Dean L. H. Bailey, when professor of horticulture, between 1894 and 1896. The first serious and comprehensive effort, however, to make a critical census and examination of conditions of apple-orcharding occurred in 1903 when the writer began the survey of Wayne county. The field work was done by Dr. G. F. Warren, then a graduate student in the Department of Horticulture. The work in the near-by county of Orleans was taken up the following year (1904) by the department, when Mr. Warren was assisted by Mr. C. A. Bues. The next year, at the earnest solicitation of the Niagara county fruit-growers, a similar examination of this county was begun. In this

instance, the scope of the inquiry was widened to include the peach. The work was continued by various assistants under the direction of the writer during the summers of 1905 and 1906, and was finally completed by Mr. M. B. Cummings, assistant in the Department of Horticulture, in 1907. During the same year the energies of the department in this survey work were divided between the east and the west. Two investigators commenced work on the apple, pear and peach in Orange county.

In the last fiscal year large progress has been made. A special fund was provided and the work prosecuted vigorously under the general direction of Professor Wilson. At the present time there have been completed surveys of six counties, viz., Wayne, Orleans, Niagara, Monroe, Ontario and Orange.

It has been thought well to offer this statement regarding the initiation of an exceedingly important line of horticultural extension effort in order that the various persons instrumental in originating and furthering it may receive due credit in future records.

MEETINGS.

The annual meeting of the American Peony Society was held at the College of Agriculture in June. This gathering brought together the leading peony specialists of the United States and Canada. The New York State Fruit Growers' Association held its summer meeting at the College of Agriculture in August, which was attended by many prominent orchardists in the State.

The writer attended and addressed during the first half year the two State pomological organizations of New York, several smaller fruit associations in addition to various granges and civic improvement societies. During the second semester he was absent on leave and spent the period in Europe where, as far as possible, a somewhat careful examination of the agricultural and horticultural schools of Germany and Italy was made. He has pleasure in acknowledging the zealous and conscientious manner in which the affairs of the department were administered by Professors Judson and Wilson during his absence.

FURTHER EQUIPMENT NEEDED.

The department is urgently in need of a storage-house for fruit and vegetables. At present, there is no safe place where fruit or vegetables can be stored for experiment or class studies. What is needed is a storage-house combining ordinary cellar storage and regulated cold-storage or refrigeration. A storage-house would enable us to conduct investigations of direct value to the grower and handler of fruit. From the standpoint of laboratory instruction in pomology and olericulture, it is equally essential.

JOHN CRAIG,
Professor of Horticulture.

DEPARTMENT OF ENTOMOLOGY.

At the beginning of the year, nearly the entire support of the department was assumed by the College of Agriculture. Under the present arrangement, a part of the salary of the Professor of Entomology is paid by Cornell University, and all other expenses of the department by the New York State College of Agriculture. The writer therefore, includes in this communication a report on all of the work of the department.

TEACHING WORK.

All of the courses announced in the Program of Courses of Instruction have been given, and have been well attended. The sum of the numbers of students attending these courses during the past year is 378. Some students attended more than one course. The numbers of different individuals were as follows:

Undergraduates	203
Graduates	16

EXPERIMENT AND RESEARCH WORK.

Several members of the staff of the department are engaged on the preparation of text-books for the use of students and general readers. These include a manual of the spiders of the United States, a book on insects injurious to fruits, a work consisting of tables for the identification of the insects of the Northeastern United States, a text-book on Insect Morphology, and a text-book of General Biology; and there was published during the year by Assistant Bradley a monograph of the Evaniidae.

Professor Needham is devoting nearly his entire time to research, a large part of which is concerned with insects and crustacea that serve as the food of fishes; this research is supported by private funds, but is conducted at the field station of the college in the Renwick marsh near Ithaca.

Professor Slingerland is devoting considerable time to studies of injurious insects, and Mr. Crosby is devoting his entire time to research in this field. During the last year, the following subjects were investigated:

(a) A study of the habits and life-history of the timothy joint-worm and other Isosomas infesting grains and grasses, with a view to devising a method to prevent the injury caused by these insects.

(b) A study of the habits and life-history of the apple-seed chalcis, grape-seed chalcis, and four other seed infecting chalcid-flies.

(c) A study of the life-history and habits of certain minor pests of the arbor vitae and the hemlock.

(d) A study of a new leaf-miner of the plum, the leaf-miner of the dewberry, and the red bug of the apple.

EXTENSION WORK.

The extension work has consisted of an extensive correspondence regarding injurious insects, a few co-operative experiments with farmers in spraying, and attendance at fairs with exhibits of injurious insects.

J. H. COMSTOCK,
Professor of Entomology.

DEPARTMENT OF DAIRY INDUSTRY.

The department of Dairy Industry has now completed its first full year in the new building provided by the State. During the greater part of last year, when the dairy work was done in the new building, the work was performed at great disadvantage, owing to the fact that the building was not completed and that workmen were constantly present in the building. During the yast year, however, the building has been free from such annoyance, and the work of the year was begun with the building and equipment in good condition for prosecuting the work of the department. In the main, the building has proved to be very satisfactory for the work for which it was intended. There are, however, some features which have been a constant source of annoyance, as a result of unsatisfactory construction in certain parts of the building.

It was generally supposed that when the department moved into its present quarters, in the new Dairy Building, there would be an abundance of room for all the desired work of the department, with plenty of opportunity for expansion. During the past year the building has accommodated the students taking dairy work very comfortably, but the number of students taking work in this department has increased so rapidly that it became evident during the year that if anything like the present rate of increase continues, the time is not far distant when the present building will not furnish satisfactory facilities for giving the instruction work in Dairy Industry. In fact, the building was taxed nearly to its full capacity during the period that the Winter-course men were here.

The work of the department may be discussed more in detail under the following heads:

TEACHING.

(a) *Regular courses.*— Four new courses of instruction were added in Dairy Industry this year, as follows:

Course 47. Dairy Mechanics.
Course 48. Fancy Cheese-making.
Course 49. Advanced Dairy Bacteriology.
Course 50. Advanced Testing.

The total number of regular students has been much larger during the past year than in any previous year. This probably is due in part to the increased facilities for doing the work, together with the

increased number of courses offered,— eleven courses being offered this year as compared with seven for 1906–07, and four for 1905–06.

The following table is of interest as showing the growth of the teaching work in the past four years:

	1904-05	1905-05	1906-07	1907-08
Course 40. Milk, Composition and Tests	..	....	62	104
Course 41. Creamery Methods	25	53	32	70
Course 42. Cheese-making	25	17	13	17
Course 43. Market Milk and Milk Inspection	15	29	29	48
Course 44. Laboratory Bacteriology	19	9	16	23
Course 45. Seminar	..	....	21	33
Course 46. Investigations	..	....	10	9
Course 47. Dairy Mechanics	..	....	....	36
Course 48. Fancy Cheese-making	..	....	....	9
Course 49. Dairy Bacteriology	..	....	....	14
Course 50. Advanced Testing Laboratory Course	..	....	....	5
	84	108	183	368

(b) *Winter-courses.*— The number of men in the winter dairy course was practically the same as for the previous year, ninety-five men being enrolled. This class showed a higher average ability than was shown by some previous classes. The men exhibited a marked interest in their work, and made a good record both as to work and to attendance. A few students were taken sick with scarlet fever, a number also had measles, and were therefore obliged to give up the work. Aside from these but few men left the course before the close. All of the men who made good records received satisfactory positions soon after the close of the course; in fact, the call for competent men for positions in factories and milk stations was larger than the number of men qualified for the work. There seems to be a growing belief among commercial men that men having some special training in the handling of milk and its products are more satisfactory than those who have not had such training.

In addition to the ninety-five men taking the regular winter dairy course, forty-eight men took the work in farm dairying, making a total of one hundred and forty-three men who received instruction in dairy work during the winter course.

RESEARCH WORK.

The rapid growth in the number of students taking work in this department has fully kept pace with the increase in the teaching staff,

so that the time of the members of the staff has been very largely taken up with the teaching work. In addition to the teaching work, however, experimental work has been conducted during the year in the following lines:

(a) Improvement of the Ithaca milk supply. The purpose of this work is to aid the farmers in producing milk of better quality more economically, and at the same time to aid the Ithaca health officer in securing a wholesome milk supply for the city. A thorough study has been made of the quality of the milk delivered in the city; also careful inspection of the farms where the milk is produced. This work has met with the approval and co-operation of the milk-producers as well as the city authorities, and has resulted in a marked improvement in the quality of the milk coming into Ithaca.

(b) During the winter months experimental work was undertaken in the manufacture of Camembert cheese. Some very satisfactory cheese was produced, but with the approach of warm weather it was necessary to give up this work, owing to lack of cool curing-rooms.

(c) Some experimental work in the manufacture of cheddar cheese has been done, especially in connection with the manufacture of soaked-curd cheese. Some very interesting results have been obtained, which have been used by the State Department of Agriculture as a basis for regulating the sale of this type of cheese.

(d) During the year the dairy department has been conducting cow testing work with something over 200 individual cows in 22 different herds. This work is being conducted in connection with our creamery at Sage. The department's representative visits each herd once a month, taking records of the feed consumed and the yield of each individual cow. This work shows the farmer which are his profitable and which are his unprofitable cows, how to keep a record of his individual animals, and it will enable him to produce more milk.

(e) A careful scientific study is being made of the fermented milk drinks now placed on the market in this country. The use of this milk is at present attracting much attention among physicians, and it is thought that a thorough study of these materials, with methods for making the same, will be of considerable practical value.

(f) Considerable work has been done on methods for market milk inspection work. There is at present no uniformity in the methods used by the milk inspectors in the various cities. It is thought that much better methods can be worked out than are in use at present. One report on this work has already been sent to the committee of the American Public Health Association appointed to consider this question.

EXTENSION WORK.

During the year extension work has been conducted by the department in the following lines:

(a) Correspondence.— Over 5,000 letters were received and answered by this department during the year. The great majority of these were from residents of New York State seeking information in regard to some phase of dairy work. It is believed that much good can be done to the dairy interests of our State by means of carefully conducted correspondence.

(b) The work of the winter-courses as outlined above.

(c) Work at Farmers' Institutes and Grange meetings. It is difficult for the members of the teaching force to be absent from Ithaca for any length of time during the University year. During the past year, however, members of the staff have attended approximately twenty different meetings, giving addresses upon various phases of dairy work. The importance of this line of work is appreciated, but with the present size of the staff and the large classes that have to be cared for, it is practically impossible materially to increase the amount of this work done. It is hoped that the time may soon come when the teaching force will be sufficiently increased so that some members will be able to spend more time in this work.

(d) The work of cow-testing mentioned above, the inspection of former winter-course students, and the securing of positions for the same may properly be included under extension work.

NEEDS OF THE DEPARTMENT.

One of the most urgent needs of the department is a good refrigeration plant. The question of milk supply for the instruction work has always been a serious one. Since the adoption of the present practice of handling the milk supply the year round in order to secure a satisfactory supply for work during the University year, it is necessary for us to handle large amounts of milk, butter and cheese during the hot summer months, which means the use of large quantities of ice. The icehouses at present available for the use of the department are not large enough to house the ice needed for the work of the department. It will readily be seen that the handling of this amount of product in a satisfactory manner requires large quantities of ice, and more has been needed during the past summer than in previous years, because cheese has been made continuously during the summer this year for the first time. In order to get the best returns for our products it is desirable to make cheese the year round in order to supply a regular trade.

During the past season it has cost the department fully $800 for ice. In addition to this cost it has been impossible to conduct certain lines of experimental work because of the lack of proper refrigeration. The installation of a refrigerating system would do away with the expenditure of this sum of money for ice, and it would also enable us to accomplish the manufacturing and experimental work much more satisfactorily.

One of the greatest needs in dairy work in New York State at the present time is a better knowledge on the part of milk-producers of the methods of producing cleaner milk. The cities drawing their milk supply from New York State are now requiring a much higher grade of milk than formerly. The margin of profit to the producer is very small. He therefore justly maintains that he cannot increase the cost of production in order to comply with the new requirements. The dairy department could do no greater good to the milk-producers of the State than to show them how they can improve the sanitary conditions of their stables and methods of handling milk without materially increasing the cost of production. One of the greatest additions to the equipment of the dairy department would be a small herd where instruction in this phase of dairy work can be given.

Many creameries and cheese factories throughout the State are losing every year thousands of dollars because of inaccurate methods of testing. If the dairy department had a man who could spend a considerable part of his time in the field, giving instruction in this line of work, it would place the department in closer touch with the manufacturing interests of the State, and would result in bringing larger numbers of students to the University. The same thing is true in the matter of conducting cow-testing work. Other states have gone far ahead of us in this, and it is hoped that we will be able soon to have sufficient help to do a greater amount of this work.

The Dairy Department should have equipment for making milk-sugar and casein. The saving of all by-products is a matter which receives the closest attention by the average manufacturing concern. This is not true in most of the butter and cheese factories in this State. Large sums of money are being lost to the dairymen every year because the by-products of the factories are not properly utilized. We should be able to instruct our students how to make the best use of the factory by-products. A room was planned for this work when the dairy building was constructed, but the department needs funds for installing the necessary machinery. The department is not doing its full duty to the dairy interests of the State until this work is taken up, and it is hoped that it may be possible to do this in the near future.

CHANGES IN THE STAFF.

Beginning with the year, Mr. Allan Ferguson, a graduate of Wesleyan University, having had two years' practical experience in the manufacture of Camembert cheese, was secured as assistant in this department to take up the work of teaching and manufacturing this kind of fancy cheese, together with the investigation work in connection with the city milk supply.

Early in April, Governor Hughes appointed Professor R. A. Pearson Commissioner of Agriculture of New York State, and on April 20th he resigned his position as head of the Department of Dairy Industry in order to take up his new duties in Albany. Professor Pearson's departure is a great loss to the department. He left the work of the department, however, very thoroughly organized, as a result of which it has been possible to continue the work without very serious interruption. The plans which he had outlined are being carried out as nearly as possible as he had planned them. The success of the work in the future will be very largely the result of the efficient organization and the plans which he outlined while still head of the department.

Just prior to Professor Pearson's appointment, Albert R. Mann was appointed assistant professor, and began his duties in the Dairy Department April 14th. Professor Mann took charge of much of the business and office work which Professor Pearson had been doing. A little later Professor Mann was appointed by Commissioner Pearson as his private secretary, and left the Dairy Department June 23d, to take up his new work in Albany.

Because of ill health, Mr. W. W. Hall, who for so many years has had charge of the instruction in cheese work during the winter-course, was unable to do the work this year. Mr. C. A. Publow, formerly cheese instructor in Canada, was secured to do this work. At the close of the winter term Mr. Publow was appointed assistant professor and began his duties in this capacity March 1st.

Mr. E. S. Guthrie, for three years instructor in butter-making in the Ohio State University, has been appointed in a similar position here, and will begin his work at the opening of the new fiscal year. Mr. Guthrie has made an excellent record in Ohio, and I believe the Dairy Department is fortunate in securing him.

The department acknowledges the generous support and many helpful suggestions given by the director.

W. A. STOCKING, JR.,
Assistant Professor and Acting Head of Department of Dairy Industry.

DEPARTMENT OF ANIMAL HUSBANDRY.

ITHACA, N. Y., *October* 20, 1908.

TEACHING WORK.

The amount of instruction given in the various courses is shown in the tabular statement below:

	1907-1908. First Term.	1907-1908. Second Term.
Course 31	82	65
Course 32	..	55
Course 33	..	2
Course 34	40	..
Course 35	..	9
Course 36	11	..
Course 37	..	7
Course 38	33	..
Winter course, Feeds and Feeding		197
Winter course, Breeds and Breeding		68

RESEARCH WORK.

The research work has been comprised mainly of feeding experiments. First, an experiment to determine the usefulness of various artificial foods in raising calves without milk. Second, the use of roots instead of concentrated foods in the production of milk. Third, the utilization of skimmed milk in feeding pigs. Fourth, the possibilities of profitable beef-production in New York State. Fifth, the economy of production of winter lambs. Sixth, the department has recently planned a co-operative experiment with feeders of lambs in Genesee county to determine, if possible, the cause of loss of lambs by apoplexy, which is common in that vicinity.

EXTENSION WORK.

The larger part of the extension work in this department is comprised in supervising the records of the production of pure-bred cows belonging

to the various breeds. During the past year, the records of 1,265 Holstein cows were supervised, 1,119 for periods of seven days each, and the remainder for various longer periods up to sixty days. In addition, regular monthly inspections of 11 Guernsey, 5 Jersey and 1 Ayrshire herds have been made.

Further, various members of the department have attended and spoken at twelve or fifteen institutes, granges and other farmers' meetings.

STAFF AND EQUIPMENT.

The staff was strengthened during the past year by the appointment of Elmer S. Savage as instructor in Animal Husbandry.

The equipment of the department was materially increased by the purchase of horses from a sum set aside from the special appropriation by the Legislature for additions to the equipment. This comprises a team of pure-bred Percheron fillies, two years old; a team of cross-bred Hackney-Standard mares for driving purposes; a team of grade Belgian geldings, representing the heavy draft type, and four teams of work horses of the better grade and of a medium draft type. This makes a reasonably full equipment of horses and teams, which the department expects to strengthen by breeding such of the mares as are available for the purpose from this time on.

The greatest need of the Department of Animal Husbandry at the present time is additional buildings for the housing of the live-stock and for beginning work in dressing and curing of meats on the farm.

H. H. WING,
Professor of Animal Husbandry.

DEPARTMENT OF POULTRY HUSBANDRY.

During the year the Department of Poultry Husbandry has made consistent growth in each division of its work. The activities of the department divide as follows: First, administration; second, instruction; third, investigation; fourth, correspondence; and fifth, enterprises in co-operation with the Extension Department.

Administration.

Many important improvements have been made which have added materially to the efficiency and appearance of the poultry plant. Five houses have been removed and remodeled and the land south of the new laying-house has been graded and seeded. As a result, there is now a modern pipe-system brooder-house, forty-five feet long, for rearing winter chickens; a fattening-house thirty feet long; a killing-room, storage-room and seven colony-houses, all of which were greatly needed. With the $2,000 appropriated by the State, a modern laying-house has been built 276 feet long, containing twenty-three pens, admirably adapted to purposes of instruction. A hot-water heating system and electric lights have been placed in the main building. A room has been properly equipped with gasoline engine, bone-cutters, feed-cutters, and the like for the teaching of poultry mechanics. In the attic of the Dairy Building a commodious, well-equipped laboratory has been provided. All the buildings of the Plant have been painted to match the color scheme of the College of Agriculture, and cinder paths have been constructed and flower beds laid out, which add greatly to the attractiveness of the Plant.

Each year students have built a laying-house and brooder-houses as part of their instruction, until now we have a capacity for wintering 1,500 head of poultry and for rearing about four thousand chickens annually.

Through the kindness of the Farm Department and the Department of Grounds, we have been enabled this year to rear chickens under somewhat normal conditions, which, heretofore, it has been impossible to do. As a result, more and better chickens have been grown, with less mortality and at a less expense than heretofore. This has resulted in a large increase in the income from the sales of poultry and poultry products.

The inventory of the Poultry Department, on July 1st, showed values as follows:

Equipments for teaching and investigating	$3,375 05
Stock	2,696 85
Feed	193 96
Buildings	5,876 50
Total	$12,142 36

The amount of stock on hand, October 1, 1908:

Young stock	3,298 head
Mature	829 "
Total	4,127 head

INSTRUCTION.

The number of students taking courses in Poultry Husbandry in 1907–8 was:

(a) Regulars, 32;
(b) One or two-year specials, 56;
(c) Winter Poultry-Course, 46;
(d) Electing Poultry Husbandry from other Winter Courses, 33.

Total students taking some form of instruction in Poultry Husbandry, 167.

TABLE SHOWING THE NUMBER OF "UNIVERSITY HOURS" TAUGHT DURING THE PAST FIVE YEARS, TO STUDENTS OF VARIOUS GRADES:

	1903-4	1904-5	1905-6	1906-7	1907-8
Regulars and specials	74	339	258	474	527
Winter Poultry Course	....	225	540	690	690
Winter Course Elective	54	60	80	64	66
Total	128	624	778	1,228	1,283

The courses taught during 1907–8 have been increased as follows for 1908–9:

Course 38 (laboratory practice during afternoons) is required of all students who take course 37 (lecture course). This makes a four-hour course throughout the year without being discontinued, as formerly, dur-

ing the twelve weeks' Winter Poultry Course. This change was made possible by the completion of the poultry laboratory in the Dairy building and the employment of additional help.

A course in fattening poultry (39b) and a course in brooding (40b) have been added. These courses have long been needed but could not be given until this year. They are now given because we have the new fattening-house and pipe-system brooder-house, recently constructed by moving and remodeling several of the original laying houses and the employment of additional help.

Students from winter courses other than the poultry course, who elect Poultry Husbandry, will be given, this year for the first time, demonstrations in connection with the lectures. This is made possible by the increased laboratory facilities and help, as indicated above.

INVESTIGATIONS.

During the year the investigational work has been greatly strengthened by being segregated from the instructional work. This was accomplished by setting apart for the investigational division, a laboratory, feed-room, incubator-room, and about one-half of the pens, each equipped for conducting the experiments entirely apart from the instruction.

Professor C. A. Rogers has given practically all of his time and Mr. A. E. Boicourt has given all of his attention to the eighteen investigational projects which have been conducted during the year, and which will furnish material for four bulletins to be prepared soon.

This branch of the work has been made more efficient by increasing the facilities for keeping records and working up a large amount of data now available for publication. Bulletin No. 258 on the "Molting of Fowls" is now in press, and bulletin No. 259 on "The Use of Grit" is nearly ready for the printer.

CORRESPONDENCE.

The correspondence has increased rapidly each year. The total number of letters written between October 1, 1907 and October 1, 1908, was 8,092. This does not include form letters and cards sent out in response to inquiries for poultry literature.

ENTERPRISES IN CO-OPERATION WITH THE EXTENSION DEPARTMENT.

(a) During the year, seven lessons on poultry have been prepared for the Rural School Leaflets. Several others are in preparation.

(b) Twenty-eight persons have undertaken various types of co-operative experiments with poultry.

(c) Five educational exhibits have been made at the State and county fairs.

(d) The number of speaking engagements which have been filled by members of the instructing staff of the Poultry Department, 1907–8, is as follows:

Number of appointments made by members of the Poultry Department for outside speaking	35
Number of speaking engagements in co-operation with N. Y. State Farmers' Institutes	6
Number of speaking engagements in co-operation with C. U. Extension Department	17
Number of speaking engagements in exchange for services of non-resident lecturers from other States	3
Number of speaking engagements in other States	4

RECOMMENDATIONS.

The increasing demand on the part of students for instruction, and poultrymen and farmers of the State for lectures, personal visits, and information through bulletins, reading-course lessons, rural school leaflets, and correspondence, demands an increase in the amount of land, buildings, equipments and help.

(a) *More land is imperatively needed.*— The Department of Poultry Husbandry, if it is to practice what it teaches, if it is to make a success of the department, as indicated by healthy stock and large percentage of fertile eggs hatched and chickens reared, and if it is to do this with an economical expenditure for food and labor, should have forty to fifty acres of land in addition to the four or five acres, approximately, which it has now. The modern poultry enterprise is a farm, not a plant. The latter almost invariably results in congestion, disease and disaster.

It is urged that the present plant be retained as long as possible in order that instruction may be given in close proximity to the main group of College buildings. A large part of the effective teaching in Poultry Husbandry must be by practice in handling fowls and general plant management. This cannot be done under existing conditions of student living, with the poultry farm located on other land, presumably now available for such purposes. The land to be devoted to the poultry farm would be used for all investigational work and for the rearing and handling of all stock during the summer season.

It is necessary that the land be provided in order to rear the stock successfully. The department is dependent on the indulgence of the Farm Department and the Department of Grounds for use of land for rearing chickens during the summer months, which, although a great improvement over conditions formerly existing, at best is only

temporary and unsatisfactory, both to the Poultry Department and to the departments that permit the use of their land.

(b) *More buildings should be provided.*— There is urgent need for a main administration building for the Department of Poultry Husbandry. The department is now dependent on the Department of Dairy Industry for lecture-room, laboratory, office and reading-room. The present poultry building is wholly inadequate to meet the demands of the students who are taking instruction. The incubator-cellar is taxed beyond its capacity. The feed-room is too small and there are not pens enough to accommodate all of the students who will seek instruction in Poultry Husbandry the present winter.

The department will be obliged, this winter, to limit the number of students in the Winter Poultry Course to fifty. It is more than likely that it will be necessary to turn away students in this State because of lack of facilities, nowithstanding the fact that we have inserted the clause that no students from outside of the State shall be given a place in the class if, by so doing, it shall debar a person from this State from entering.

(c) *More help is required.*— In order properly to teach the students who seek instruction there should be an assistant professor appointed, in the near future, who shall devote his entire time to instruction.

(d) *Poultry exhibits at the fairs should be extended.*— The Department of Poultry Husbandry could use funds to splendid advantage and with great profit to the poultrymen in placing an educational exhibit at every town and county fair in the State, where suitable accommodations could be provided.

(e) *Poultry associations are effective centers for work and should be assisted.*— There are forty or more poultry clubs, societies and associations in this State, a very large proportion of which would welcome one or more speakers each year to attend these meetings, especially in connection with their poultry shows, where educational exhibits should be displayed.

(f) *A poultry survey would result in great good.*— There should be a poultry survey made of Tompkins county and other counties of the State at the earliest possible date. Much valuable information can be gained by comparison of methods as they are actually practiced by farmers and poultrymen in this State. This type of information is wholly lacking and decidedly needed at the present time.

James E. Rice,
Professor of Poultry Husbandry.

DEPARTMENT OF FARM MECHANICS.

Teaching Work.

The teaching work of this Department during the past year consisted in a three-hour course entitled "Farm Mechanics," for which 34 students were enrolled in the first half year and 40 in the second half year. For the coming year, this Department will offer "Farm Mechanics" in the first half year and during the Winter-course, and "Farm Engineering" in the second half year, the last being provided in response to the frequently expressed desire of many of our students.

Before laying out the work of either of the above courses it was thought best thoroughly to canvass the entire field of agricultural engineering and to decide in detail on the subjects and the amount of time which it would probably be best eventually to allot to each of the Departments of Farm Mechanics, Rural Engineering and Rural Architecture, as broadly outlined in the report of the Director for 1905–1906. Tentative schedules were therefore prepared for two sets of courses, one set being laid out to suit the requirements of the general student, and one to suit the student who wishes to specialize in engineering work.

Courses for General Student.

	University Credit Hours.		
	Laboratory.	Lectures or Recitations.	Total
Shopwork	2	....	2
Farm Mechanics	1	2	3
Farm Engineering	1	2	3
Total	....	....	8

Courses for Specialist.

	Laboratory.	Lectures or Recitations.	Total
Drawing — Instrumental	1	....	1
Shopwork	2	....	2
Farm machinery	2	1	3
Farm Motors	2	1	3
Field Engineering	2	1	3
Rural Architecture	2	1	3
Total	....	....	15

At the present time, the minimum number of unrestricted elective hours in the College of Agriculture open to a regular student is 38, the maximum 56. The complete short set of courses in engineering as outlined above would constitute approximately 21% of the minimum or 14% of the maximum number of said elective hours; the complete long set of courses, 39% of the minimum or 27% of the maximum. As it would frequently happen that a student would not be able to devote so great a proportion of his elective hours to engineering work, these courses therefore should be laid out so that so far as possible one would not be a prerequisite of any other.

Drawing. By way of preparation for either of these sets of courses it would be urged that the regular students so elect their work in drawing that one of the two required hours be spent in freehand and the other in projection or instrumental drawing. In addition to this, it will be noted that students intending to specialize in engineering would be urged or possibly required to take one more hour in instrumental drawing, provisions for which now exists in the college curriculum.

Shopwork, the same for both sets of courses, would be intensely practical, dealing with such subjects as construction of building frames and of forms for concrete work, simple forging and the tempering of steel, the adjustment and repair of agricultural implements and wagons, painting and varnishing, and the cutting and fitting of pipe.

Farm Mechanics, the course given during the past year, would aim constantly to bring out fundamental principles and to train in clear thinking in connection with the study of a few farm implements, pumps and farm motors. Like the shopwork, the illustrations cited in the lectures and the exercises set for the laboratory work would be intensely practical in nature, in order to arouse and maintain the student's keen interest in the work.

Farm Engineering would treat of the practical solution of the problems involved in connection with farm sanitation; surveying and mapping the farm; laying out, grading and digging drainage and irrigation ditches; laying out and building farm fences, roads and bridges; laying out building foundations, testing the use of cement, etc., etc. No attempt would be made to include rural architecture in this course, as the time allotted is much too short even for the subjects first mentioned.

Courses for the Specialist. The extended courses of the second set having double the amount of laboratory work, would require ample laboratory space, equipment and instructing staff properly to handle any considerable number of students.

Dairy Mechanics and Poultry Mechanics. It would seem to be advisable ultimately to have the work in Dairy Mechanics and in Poultry Mechanics now given by the Dairy and Poultry Departments respectively included in

the work of the Department of Farm Mechanics. Whether or not instruction in particular parts of the work should be given by a member of the department involved would be a point to be settled by circumstances existing at the time.

Highway Construction, a matter of far-reaching importance to the rural districts, should be provided for in a separate course designed especially to train men for the position of road supervisor. The aid of the National Department of Agriculture could undoubtedly be secured in this work in the way of supplying machinery and materials for demonstration and exhibition purposes.

Winter-courses. In addition to the winter-courses in Farm Mechanics, Dairy Mechanics and Poultry Mechanics now being offered, there should be provided winter-courses in Farm Machinery and in Highway Construction.

Advanced work. Opportunity should be provided for advanced work in (a) Farm Machinery along the lines of testing and improving machines of existing types and also of designing wholly new machines, the need for which might be brought out from time to time as the result of or in connection with research by other departments. (b) Farm Motors. (c) Field Engineering on drainage and irrigation problems, highway construction and maintenance, tests of fencing, etc. (d) Rural Architecture, along any of the numerous lines that at once suggest themselves.

Separate Courses for Specials. In all of the engineering work, the need of separate courses for fully-prepared regular and for unprepared special students is most pronounced.

RESEARCH WORK.

No investigations of any kind were attempted during the past year. During the coming year, however, there will be made a thorough investigation of spray nozzles under all laboratory conditions which, it is hoped, will prove of much practical value.

A special appropriation of $100.00 will be devoted to the purchase or construction of a traction dynamometer of the best possible design, which will be absolutely essential in much of the research work that may be taken up later.

EXTENSION WORK.

As the department is but recently organized and not yet fully established, no attempt was made during the past year to undertake any aggressive extension work, and since the department is practically unknown to the farmers of the State few letters of inquiry on engineering subjects were received. Of these few, however, a number contained requests for advice as to the best make of implement of some kind for the inquirer to purchase.

This at once brings to our attention a phase of the Farm Mechanics' work which will require the most delicate handling. The farmers will expect the department, and reasonably so, to act on occasion as their consulting engineer in matters pertaining to the selection of their machinery. On the other hand, the greatest care must be exercised to avoid injuring the trade of any manufacturer by carelessly condemning his goods without just cause. Since the work is supported by the people of the State they have a right to demand results. This forces us to the conclusion that the only just course is to issue no statement actively derogatory or especially commendatory of any implement or machine unless such statement is founded on facts obtained by accurate tests conducted under thoroughly fair and fully specified conditions. To this course, the writer believes, neither the farmers nor the majority of the implement trade can offer reasonable objection.

There are, however, many other lines in the way of general education in engineering matters in which the work of this department may be extended to the farmers of the State and this work will be taken up at the earliest possible moment.

CHANGES IN THE EQUIPMENT.

On its organization, this department received from the old Agronomy Department, under whose charge the work had been previously done, a considerable equipment of machines, notable among which are a number of plows both walking and sulky, a threshing machine complete with many attachments, a traction engine, and a number of historical implements. Mention should also be made of the set of copies of the Rau plow models secured by President Andrew D. White in Germany in 1868.

During the past year, much attention was devoted to the task of bringing the work and aims of the Department of Farm Mechanics to the attention of a number of the larger manufacturers of agricultural implements and machinery throughout the country and of soliciting their aid in the way of furnishing catalogues for distribution and machinery for use for exhibition purposes or in connection with the laboratory exercises. It is a pleasure to report that these letters have been met invariably with courtesy and with a ready acquiescence to practically every request made. Among the most important additions to the equipment may be noted three gasoline engines, a six foot windmill on stub tower, several pumps, a sectioned pump model, engine lubricators and other fittings for laboratory study, three grain-binder attachments, a grain-drill, and a garden seed-drill. Owing to lack of room, the department was obliged to refuse the loan of a second threshing machine and traction engine.

There were also designed and purchased by the department two testing or calibrating stands, one for grain-drills, the other for garden seed-drills; three stands for mounting the binder attachments mentioned above; five benches; models illustrating methods of igniting explosion engines, and a stand for supporting these and similar models.

Over one thousand trade catalogues, price lists, leaflets of instructions for operating special machines, and the like, have been collected, classified, carefully catalogued and filed so as to be readily available for reference. The work of cross-indexing will be perfected as funds and opportunity permit.

RECOMMENDATIONS.

During the past year this department relinquished its claim to the larger of its two rooms which has since been converted into a laboratory for the Department of Soils, whose old quarters are now occupied by the Department of Plant Physiology. In addition, the latter department has received a conditional promise that it shall have next year the small room directly beneath it now occupied by the Department of Farm Mechanics, thus leaving that department without accommodation.

It is possibly in order at this time to note that in his inaugural address in 1892, President Schurman recommended "a museum for the exhibition of all kinds of agricultural implements" as one of the important departments to be housed in the new agricultural buildings when they should be secured. The Stewart-Monroe bill providing for the erection of these buildings directs that provision shall be made for the exhibition of machinery. It would thus appear that if the changes now proposed are carried out, it will be absolutely necessary next year to make some other adequate provision for the housing of the Department of Farm Mechanics.

Two courses present themselves: Either to go to the Legislature at once for money for a new building or to make use for the time being of quarters which would next year be available. Considering the needs of other departments of the College, money for which must be secured in the near future, it would probably be impossible to secure at this time funds sufficient for a suitable building, and the writer would respectfully urge that no new building be attempted until such time as there can be had one of capacity and appointment amply sufficient for the needs of all of the engineering departments of the College for some years to come. Furthermore, owing to the youth of the Department of Farm Mechanics its requirements cannot now be accurately foretold, and as this department would occupy

the largest part of an engineering building this constitutes another argument against the construction of a new one at this time.

The old University barn as soon as it is vacated, following the completion of the new barns now under construction, will be available for some purpose and with moderate alterations could be made suitable for the use of the Department of Farm Mechanics, for say five years to come. In the basement could be located the shops and a steam engine, the exhaust steam from which could be used for heating the shops, the offices and the one or two laboratory rooms on the floor above. All the remainder of the building would be unheated and used mainly for exhibition and storage of machinery, the present haymows being floored over for the purpose. Implements to be studied would be run into the heated rooms when required. In order to reduce the fire risk it would be highly desirable to use as a separate gasoline engine room the two upper stories of the present addition to the east of the horse barns, which could be moved down to the ground at the north of the main barn. Should this plan prove too costly, however, some provision for this work could possibly be made in the main building, but the restrictions imposed by the insurance companies for the use of gasoline engines in buildings would materially hamper this important part of the work.

While there has been figured no accurate estimate of the cost of the necessary changes in the barns, including the removal of the cupolas and the putting on of a much needed new roof, it is probable that the work could be done for the sum of $5,000. Money required in addition to this amount, if any, would be invested in movable equipment which could be used in the new building when obtained.

Adequate quarters having been provided, it would be necessary at once to add at least two persons to the instructing staff of this department, one to assist in the laboratory instruction, and the other to be foreman of the shops. Funds should also be provided for the employment of a stenographer for at least half of each day, as the writer is now obliged to spend in work of a purely clerical nature many hours which might otherwise be employed much more to the advantage of the department.

While considerable research work can be conducted by the aid of advanced students, it would be advisable eventually to appoint a thoroughly competent experimentalist to work under the direction

of the head of the department. In this way, much more and probably more exact work could be accomplished.

It will also be necessary in the near future to set aside somewhere within easy access of the College a piece of ground for use in conducting class work and in making experiments with agricultural implements and ditching machinery.

HOWARD W. RILEY,
Instructor in charge of Department of Farm Mechanics.

DEPARTMENT OF AGRICULTURAL CHEMISTRY.

The work for the past year has been about equally divided between teaching and experimental work.

Teaching Work.

In the teaching department, instruction was given to 48 regular students of the sophomore year during one term (the instruction included laboratory practice twice a week). A separate course of lectures was given to about 75 special students. During the winter-course, 125 students attended a course of lectures arranged for them. The separation of the special and regular students sems to be very satisfactory, allowing a more advanced grade of work to be given to the regulars.

Experimental and Extension Work.

The experimental work, which is conducted under an appropriation from the State fund, has consisted chiefly in making chemical analyses of materials sent in by other departments. A large number of moisture determinations have been made of crops grown for experimental purposes. The requests for analyses of various materials, as soils, fertilizers, feeds, insecticides, from the residents of the State, is increasing rapidly and now takes most of the time of the assistant in the laboratory. This work is done as part of the extension work of the department.

Some preliminary work was done on the moisture and sulfur content of evaporated apples, but time and material were not sufficient to warrant publication. It is planned to continue the work this fall. If the coming year brings an increase of students and any marked increase in the demand for analytical work, the facilities of the department will be taxed, and increased room and assistants will be necessary.

GEORGE W. CAVANAUGH,
Assistant Professor of Chemistry.

EXTENSION OFFICE.

Teaching Work.

The only Collegiate teaching in this department is that with a class in Extension Work numbering 55 persons. The features of this work are the organization of agricultural information of a practical nature and practice in the technique of oral presentation of such information.

Extension Work.

The extension work consists partially in conducting the Reading-Course for Farmers. Last year, 6,600 persons were in close touch with our Reading-Course matter.

Active Correspondents.

Mailing list, active:	
Old readers renewed	525
New readers	998
Total active readers	1,523
Others not enrolled as active	5,100
Total distribution	6,623
Total number of Farmers' Reading Course clubs	21
Number of letters written	13,555

A large number of lectures were delivered by representatives of the office, besides the arranging of a number of lectures from representatives of other departments. Close attention was given to certain phases of Extension Work in the schools, especially in the introduction of agriculture in the country school and the high school. The Farmers' Week was held for the first time last February. It drew together some eight hundred persons interested in agriculture, who wanted definite instruction. A large number of agricultural organizations were entertained at the College. A notable feature was the Rural School Picnic held on the 29th of May. The New York State Agricultural Experimenters' League with a membership of eighteen hundred was kept intact and experimental work

was laid out, prizes for which were awarded during Farmers' Week. In connection with these different lines of activity, a heavy correspondence has been developed.

RECOMMENDATIONS.

The writer believes that the keynote of the work lies in more personal contact with people who want practical information, and the development of a system which will handle the details in furthering such an end. The writer therefore recommends that his work draw more heavily on stenographic assistance and such departmental aid as is necessary to get satisfactory information on the technical questions. The promotion of the work must call definitely for all or part of the time of some person in each one of the departments connected with extension work, that the proper attention may be given to the problems in the field. These persons, while remaining under the direction of their own departmental heads, would confer with the Extension Office and with other persons doing a similar work in their respective departments. This would result in general extension conferences for the purpose of caucusing opinion and systematizing efforts in the field.

CHAS. H. TUCK,

Assistant Professor of Extension Teaching.

HOME ECONOMICS.

FARM HOME EXTENSION.

Farmers' Wives' Reading-Course.—The work of the Farmers' Wives' Reading-Course is first for the individual member and second for groups of women comprising farmers' wives' clubs. September 30, 1908, shows the following membership in the Farmers' Wives' Reading-Course:

Series 1	1,442
Series 2	1,632
Series 3	2,059
Series 4	6,878
Series 5	4,461
Series 6	7,228
Total	23,709

The bulletins sent out in each series are five each year as follows:

Series I. *Farmhouse and Garden.* (1) Saving Steps; (2) Decoration in the Farm Home; (3) Practical Housekeeping; (4) The Kitchen-Garden; (5) The Flower-Garden.

Series II. *The Farm Family.* (6) The Rural School and the Farm Home; (7) Boys and Girls on the Farm; (8) Reading in the Farm Home; (9) Home Industries; (10) Household and Garden Pests.

Series III. *Sanitation and Food.* (11) Home Sanitation; (12) Germ Life; (13) Human Nutrition; (14) Food for the Farm Family; (15) Saving Strength.

Series IV. *The Farm Table.* (17) Flour and Bread; (18) Dust as related to Food; (19) The Selection of Food; (20) Canning and Preserving.

After the fourth year the bulletins have been on subjects already introduced into the previous bulletins and are a further treatment of these subjects. A four-page discussion paper accompanies each bulletin. This

contains questions with space for answers by the members. It is to be returned to the supervisor of the reading-course for review. Opportunity is also given to members to ask questions on domestic problems. These questions, when necessary, are referred to the departments specializing in the subjects to which the questions refer. The last year has shown much advance in correspondence with members. Questions are asked concerning the destruction of household insect pests, how to fumigate a house after contagious diseases, how to preserve eggs, how to can vegetables. Lists of books for the home are asked for both for children and for those desiring special work in farming. Recent inquiries are, Is there danger of ptomaine poisoning in the use of the hay box? Is wheat starch for laundry purposes available on the market and what are its advantages over other starch? Send diagram and description of a septic tank for use in connection with the farm home. More and more the Agricultural College is becoming an experiment station for the farm home as it has been for the farm. A fuller and better equipment is constantly needed for this purpose.

The Farmers' Wives' Club.—Attention has been given during the past three years to the organization of the farmers' wives' clubs. There are now thirty-one active clubs with a total membership of nine hundred. These clubs meet usually at the home of some member at intervals of about two weeks. A program is given at these meetings which is partly literary, and which also admits of discussions on woman's work in the home. The basis of these discussions is found in the Cornell farmers' wives' bulletins. The object of these meetings is to afford to rural women social opportunities in their own communities and mental growth which is stimulated by reading and discussion. The regular meetings of farmers' wives' clubs are usually held in the afternoon at the home of a member, the women doing their own driving, while special meetings are held frequently in the evening with an attendance of men and a program on home and farm subjects of interest to both men and women.

Traveling libraries.— The extension work has been aided by the use of traveling libraries from the Department of Education, Albany. The Cornell bulletins for farmers' wives can be only suggestive studies on various subjects. They are written to arouse an interest in the subject, and at a later stage in progress, books are necessary for the completion of the work. Many clubs and groups of women have availed themselves of these traveling libraries, which may be secured for the use of clubs for a nominal fee to pay cost of transportation. Progress is particularly noticeable where the traveling library has been used.

Recommendations.— In view of an awakened interest in farm communities in the study of scientific home-making, in view of the dependence of everyone on the proper sanitary conditions in farm homes, and because of the existing conditions regarding water-supply and drainage, we recommend a larger appropriation for the women's work. The amount already appropriated supplies only in a meager way the printed bulletins asked for, the maintenance of experimental work for simpler and better housekeeping and the clerical help needed to answer questions and maintain the mailing lists. The present appropriation has furnished the means for awakening enthusiasm through the State but it does not provide adequately for sustaining the work. More and more are visits to clubs and granges asked for and the present appropriation is not adequate for the work. New York State has taken the initiative in extension work for women. It should continue to lead in its further promotion. Other states are fast following its lead and should continue to see New York in advance.

WINTER-COURSE IN HOME ECONOMICS.

Three years ago a winter course was established in Home Economics. This is primarily for the farm home: to furnish to young women the help necessary to create an interest in farm home life which will justify their staying on the farm; to place the work in the farm home on the same scientific basis as the work on the farm. The course offers instruction in nutrition, sanitation, house construction, furnishing and general management. In addition it is arranged to give women in attendance an opportunity to study out-of-door farm industries in which women frequently engage. There are at least twelve periods a week, for three months, including two or more laboratory periods weekly in which the members of the class do practical work.

A FOUR YEARS' COURSE IN HOME ECONOMICS.

As an outgrowth of the reading-course and winter course of lectures at the University, there has been developed a regular four-year course in Home Economics. An urgent need has long been making itself felt for more scientific training for women in household affairs. In some places practical education for women has kept pace with other educational advantages, but, on the whole it has lagged. It is often easier for the woman to become proficient in languages, mathematics or abstruse sciences than to put herself in possession of those scientific facts which underlie

the proper care of a home and children. It is in recognition of this need that many agricultural colleges offer courses in Home Economics.

In the fall of 1907, the College of Agriculture at Cornell University offered for the first time regular instruction in Home Economics. A laboratory was equipped for experimental purposes and courses were outlined which should run through the four college years and lead to the degree of the college. The object of these courses is to prepare the woman to meet her home difficulties in the same scientific spirit as the trained engineer, to enable her to plan as thoughtfully for human nutrition as the educated farmer plans the balanced rations for his stock.

In outlining courses in Home Economics the needs of two classes of students were considered: those wishing a general knowledge in home topics but lacking the necessary scientific foundation for advanced work, and those who have had certain prerequisite courses in science and who are prepared to study the subject in a more detailed and technical manner. It was recommended that a schedule separate from that of the regular College of Agriculture be introduced to meet the needs of this second class of students, as the prerequisites for instruction in Home Economics should differ in part from those in Agriculture.

The laboratory equipped for the department was not ready until February, 1908, and the plans for instruction in the four-year course were not matured until later in the year, so that no students were registered for the four-year course in Home Economics. Two general courses were offered in Home Economics in the second term. One was a three-hour course in nutrition and the other a two-hour course in sanitation and household management. These were for students of any other department in the college or any other college in the University. Thirty-six students were registered in these courses.

Recommendations.— While the equipment of the laboratory is at present adequate to fill the needs of a limited number of students, a need has already been felt for space to equip a small kitchen which shall represent in a practical way a model for the housekeeper. The present appropriation is altogether inadequate to allow for more than bare running expenses, and if the department is to plan for growth it is recommended that a larger appropriation be made for added facilities, equipment, service and space.

MARTHA VAN RENSSELAER,

Supervisor Farmers' Wives' Reading-Course and Lecturer in Home Economics.

FLORA ROSE,

Lecturer in Home Economics.

RURAL SCHOOL EDUCATION AND SCHOOL-GARDENING.

Rural School Education.

The major part of the work in Rural School Education is a correspondence course for teachers and children in rural districts. Last year 41,000 school children and 4,000 teachers in New York State were reached. As a basis for the educational work, there are published each month the Cornell Rural School Leaflets, one for teachers and one for children. The teachers reported on work conducted under the direction of this Department by means of the Leaflets, and thousands of letters on country life subjects were received from childen. In the teachers' Leaflet, lessons were given in many lines of agriculture by experts in the several departments at the College. General outdoor study was given for the young children and elementary agriculture for the pupils in the more advanced grades.

An effort was made to investigate the need of apparatus in rural schools to aid in agricultural instruction. Materials were sent from the College, helpful in working out some of the lessons. Among other things, an offer was made to send a Babcock milk test machine to each of the first ten persons in ten different counties in New York State who would request them. Six weeks after the announcement was issued, fifty rural school teachers had applied for the apparatus. In some of the smallest rural districts, the machine was used not only for instruction in the schoolroom but for instruction at Farmers' meetings, grange meetings, and the like, in the vicinity. Children made tests of the milk from cows in the neighborhood. The ten small machines cost about $50 and did good service. A few of the districts to which these machines went have purchased apparatus as permanent equipment for the school, and some training class teachers have added them to their laboratory equipment.

In addition to the work in the schools, there has been started, by means of the Leaflets, the organization of Farm Girls' Clubs and Farm Boys' Clubs throughout the State. These Clubs will be under the direction of a farmer in the community who will help the young persons to organize their Clubs, and to do some useful work relating to country life.

An effort is being made from the College of Agriculture to direct recreation for farm boys and girls. It is hoped to be able to standardize some

good forms of play. The effort is to encourage games to be played not only in the school yard and about the farm home, but that will open up the way for wholesome competition at country picnics and county fairs. Through the pages of the Rural School Leaflet the Department will endeavor to help direct the play hours of rural children.

In brief, it is the purpose of this department to help, in the most all round way, the boys and girls living in the country; to give suggestions for better knowledge of farm work; for better reading; for better forms of amusement in and about the farm home. An effort has been made during the past year to send lecturers to teachers' institutes and other educational meetings. Correspondence is kept up with institute conductors, school commissioners, school superintendents and other persons interested in educational matters, that the department may know the point of view of persons who have to do with the public schools of the State.

SCHOOL-GARDENING.

A course in School-Gardening is given for the benefit of persons who intend to give instruction in gardening. This consists in actual garden-making with children on school grounds and in the University school gardens. In winter, the work is conducted in the college forcing houses. There were nine students in this course the past year, all of whom expect to teach when they leave college.

NATURE-STUDY AND ELEMENTARY AGRICULTURE AT THE CHAUTAUQUA SUMMER SCHOOL.

The work done by the New York State College of Agriculture at the Chautauqua Summer School was in two departments: first, general nature-study and biology; second, school-gardening and elementary agriculture. The larger part of the work in school-gardening and agriculture was conducted by Professor C. H. Tuck and Mr. M. P. Jones; the pedagogical work in nature-study and biology by Mr. Arthur Allen and the writer.

The Chautauqua Institution and the New York State College of Agriculture for a number of years have co-operated in the nature-study movement. This year the College of Agriculture paid the expenses of the writer, and the Chautauqua Institution paid the expenses and salary of her assistant. There were in the classes about 80 students, nearly all of whom studied during the entire course, spending three to four hours a day in nature-study work. In this way, it was possible to send teachers back to their schools with definite subject-matter and methods of pre-

senting it. During the four weeks about forty New York State teachers were taught. The Institution has provided all equipment for this work, so that the opportunity is good to help teachers to appreciate the value of knowledge based on scientific facts.

In the spring, the writer spent a few days in Chautauqua in order to get a school-garden started. The purpose of this garden was to demonstrate ideas in school-gardening in villages, as well as in rural communities. There were about 350 feet of border, 8 feet wide, which surrounded central plats planted with vegetables and flowers by school children in the neighborhood. Another piece of ground was planted under the direction of Professor Tuck. The garden was used also for the instruction of teachers at the Institution held at Chautauqua in September.

The writer feels that the foundation has been laid for effective agricultural work in the large summer school on the Chautauqua assembly grounds. The administration realizes the educational value of this work and is willing to further it in every way. Next year, it is planned to demonstrate in the garden the cultivation of garden products, annual and perennial flowers, and as many vines as will grow in that climate. Experiments in farm crops will also be given, that teachers and farmers in Western New York may be instructed during the summer school session.

Course at Chautauqua: Nature-Study and Agriculture.

I. *Lecture course in nature-study for teachers and parents.*— This course is designed to give teachers and parents a comprehensive outlook to the teaching of nature-study. Suggestive lessons will be given for instruction in school and home. Persons taking this course will be prepared to carry on lines of out-of-door study intelligently. Representative lessons will be given on birds, trees, wild flowers, garden plants, earth-science subjects, and the like. Literature along outdoor lines will be discussed so that persons will be able to continue study after completing the course. Nature-study will be discussed from the standpoint of its educational, practical, aesthetic, and ethical value. Enough subject-matter will be presented to give teachers a starting place for future work.

Miss Alice G. McCloskey.

II. *Field work.*— The time in this course will be given to field and laboratory work. Birds, trees, wood plants, and wayside plants will be studied afield. Some work will be given on insect life, and teachers will be instructed in methods of making a collection of insects. Wild life of field and forest will be discussed. The making and stocking of terraria

and aquaria will be demonstrated. Any student taking this course should be able to get definite foundation for out-of-door study.

Mr. A. A. Allen.

III. *Bird work.*—For students who care to specialize in bird study there will be an early morning class. This is the time in which birds can best be studied, and since there are large numbers of birds on the Chautauqua grounds the course will be most attractive and profitable. The field work will be strengthened by talks on life history of the common birds.

Mr. A. A. Allen.

IV. *Gardening.*— This course is planned to demonstate the educational value of gardening. There will be a piece of ground under cultivation, on which teachers will conduct experimental work. There will be discussions and demonstrations regarding the growing of garden plants, vegetables, and flowers. Lectures will be given on the preparation of the ground; use of farm implements; soils; seeds; fertilizers; cultivation of crops, etc. There will be plats cultivated by children in the neighborhood from which teachers may gain experience in conducting school work in gardening. From these plats there will be opportunity to learn what children can and will do in this line of work. There will also be opportunity for teachers to judge the work of children, since the students taking this course will award prizes on the work done by the children.

ALICE G. McCLOSKY,
Supervisor of Nature-Study.

HOME NATURE-STUDY COURSE.

During the past year, the editors of the Home Nature-study Course have made special effort to render the teaching of nature-study and gardening easy for the untrained teacher, believing from past experience that the information leaflet affords the most direct method for introducing nature-study subjects into the public schools of New York State. The lessons in these leaflets have dealt with subject-matter suggested in the Syllabus of Nature-study issued by the State Department of Public Instruction, and covers the more important work of the fourth grade and some subjects in the fifth grade. In each lesson, there is indicated the object of the lesson, the material needed and the best way to secure it, and there is given a series of questions covering the observations which the pupil should make. These questions are in each case followed by a paragraph giving the teacher the facts concerning the topic of the lesson and suggestions as to methods of teaching it.

This plan seems to have helped the teachers very much; and because they have felt sure of the subject-matter they have gained confidence in themselves, which has led them to give more time to nature-study. Many letters received from the teachers who have used the leaflets contain expressions of satisfaction with this method of presenting the lessons, and never before has the demand for the leaflet been so great. A large number of lessons sent in by pupils of the public schools last year dealt with the topics given in the Home Nature-study Leaflets, thus proving that these leaflets were used widely.

There have been published during the year four leaflets and one supplement, making in all 128 pages containing 76 nature-study lessons, and also detailed directions for the planting of fall bulbs, the planting and care of school gardens and grounds, vacation lot gardens and laboratory gardens; directions were also given for selecting and planting trees, shrubs and perennials. The nature-study lessons, while giving some attention to wild life, have been devoted, for a large part, to the study of domesticated animals, birds, trees, cultivated flowers and garden vegetables.

The department has received 1,200 letters and postals during the year

and has sent 1,000 letters and 3,000 postals to teachers, and 100 postals to the training class teachers. It has sent the following leaflets:

October–November	3971
December–January	4447
February–March	4750
April–May	4750

All of the leaflets of the last two issues were sent except the 250 reserved in the files. The department was unable to meet the demands for these leaflets, and was obliged to send only one leaflet for two pupils in many of the training classes. Although the leaflets have not demanded that lessons be sent in return, the writers have received during the year 660 lessons, which were sent voluntarily by the recipients of the leaflets.

For the future of this work, it is earnestly recommended that the leaflets dealing with the subject-matter of the State Syllabus of Nature-study be published in book form sometime during the year 1909–10. This seems the only way of meeting the special need of the teachers of the State, since our own appropriations are not sufficient to keep these leaflets on hand in sufficient numbers to supply the demand.

ANNA BOTSFORD COMSTOCK,
Lecturer in Nature-Study.

JNO. W. SPENCER,
Extension Work.

DEPARTMENT OF RURAL ART.

The course in Rural Art has now proved its value in the college curriculum, not only by the number of students desirous of registering in the work it offers, and the apparent good the course seems to have done for those who have elected it, but by the constantly increasing interest in the out-of-door life generally. The value of the course in helping to bring before the people, particularly of the rural districts, a better understanding of the possible beauty of their home surroundings, has elected it for a use which will become known more and more as the work of the course advances.

There have been many difficulties experienced in the formation of the course, but the present year sees it, in every way, better equipped and able to place before the student the full value and meaning of rural art, or make of him a well-trained landscape designer. Future changes should be in the detail of the course, rather than in its general outline or policy.

The greatest inconvenience so far has been the coming for instruction of students who were not entirely prepared for this work, lacking many of the prerequisites,— generally juniors, or seniors, with but one or two years to give to the work. The course, too, is as yet hardly sufficiently well known for students to enter the college with a recognized purpose of electing the work. They generally learn of its merits after a year or two of residence, spent in preparing themselves for some other branch of agriculture having other prerequisites.

As a means of clearing the course of this and some other minor difficulties, a committee has been appointed by the director of the college to look over the course, primarily with regard to its detail arrangement, with the purpose of bringing about a better relation between it and the other departments of the college and the university. To aid the committee in its work, the writer has drawn up a four years' schedule of the course.

In addition to this feature of the committee's work, some minor changes have been suggested for immediate consideration. We mention here only the change suggested relative to Course 86, treating of the Organography of plant Material of Landscape Gardening. This course, as now given, allows the student to enter with only a botanical knowledge of plant materials, and it remains for the course to teach him, not only the

landscape use and value of trees and shrubs, but their identification, which is not possible in the time allotted to the course. As a remedy, Course 86 should be divided into two courses,— a preliminary or prerequisite course which would teach the identification, characteristics and propagation of plant materials, and a revised Course 86, dealing more distinctly with the landscape value of plant material. It is suggested that this preliminary course be given in the Department of Horticulture, with possible aid and suggestion from the Department of Rural Art, and should be required as early in the course as convenient, preferably in the Sophomore year following the Freshman botanical study.

EQUIPMENT.

Since the presentation of the last report, sufficient money has been placed at the disposal of the department to equip it well. The past year's appropriation was spent largely on surveying instruments and photographic or slide illustrations. Office equipment was given little consideration, except for the purchase of a desk and a slide case, the office still being a part of the general office of the Secretary of the College. The present college year has seen a change for the better, and the department is now located in a small but convenient room opening off the corridor of the main building, giving the department a headquarters of its own, and allowing for better office organization.

Sufficient drafting room space is still available in the College of Architecture, and in consequence, even though space is now at the disposal of the department in the College of Agriculture, it has been thought best to continue the drafting work there for the coming year.

STAFF.

The teaching force consists of two members, an assistant professor and an instructor. The work of Professor Baker in free-hand drawing is closely allied to that of this department. The staff is adequate for the present needs of the course, especially when supplemented by special lectures given by men of practical experience, such as architects, nurserymen and park superintendents.

A change has occurred in the personnel of the instructing staff, Mr. Taylor having resigned at the close of the last college year, to accept a position in the office of an eastern landscape-designer. In his place has been appointed Mr. George C. Burnap, a former student and traveling fellow in landscape architecture at the Boston Institute of Technology.

In addition to the teaching work of the department, it is the intention to bring to bear as strong an influence as is possible in the improvement of rural school grounds. To accomplish this, the department, through the teachers' leaflets issued by the college, will publish a series of short articles on "Rural Art — Its Meaning and Possibilities." It is proposed to offer, through these leaflets, to make plans for the arrangement and improvement of the first ten rural schools sending to the department the proper information on which to judge and base such recommendations, stating that but one school in a county will be considered. In so reaching the school, the department will indirectly reach the rural home. It is hoped to be able to send from the department, not only additional literature, but an occasional lecturer whose duty it will be to explain the solving of the simpler landscape problems, and to instill into the minds of the listeners the value of good school and home surroundings.

Mention should be made of the ground improvements which are being made about the new buildings of the college. During the Spring term of last year, a complete road and planting plan was made for the immediate surrounding of the building, the plan being studied with reference to extensive proposed future improvements of the entire University property. The roadways in the immediate vicinity of the buildings were built last spring, and a considerable amount of planting done, which is this fall fast nearing completion.

BRYANT FLEMING,
Assistant Professor of Rural Art.

Statement of expenditures, fiscal year 1907–1908, under State appropriation for the promotion of agricultural knowledge throughout the State and for the maintenance, equipment and necessary material to conduct the New York State College of Agriculture.

September 30, 1908.

Salaries	$61,876 52
Office and printing	17,243 09
Farm maintenance	12,000 00
Farm crops	1,002 91
Soils	849 81
Chemistry	326 93
Plant physiology	1,566 67
Plant pathology	780 34
Entomology	492 38
Horticulture	5,010 84
Animal husbandry	3,477 69
Poultry	3,716 18
Dairy industry	9,000 00
Rural art	421 21
Farm mechanics	330 24
Home Economics	480 00
Reading courses	2,500 00
Extension	3,064 09
Nature-study	3,257 38
Rural economy	200 00
Graduate school	3,552 43
Heating buildings and forcing houses	3,000 00
Lighting	932 75
School gardens	39 13
Engineer, janitors, watchman, etc	5,737 77
Planting grounds	1,368 46
Balance to complete purchases and expenditures contracted for but not yet completed so that actual payment could be made	7,773 18
	$150,000 00

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The regular bulletins of the Station are sent free to persons residing in New York State who request them.

JANUARY, 1908 BULLETIN 250

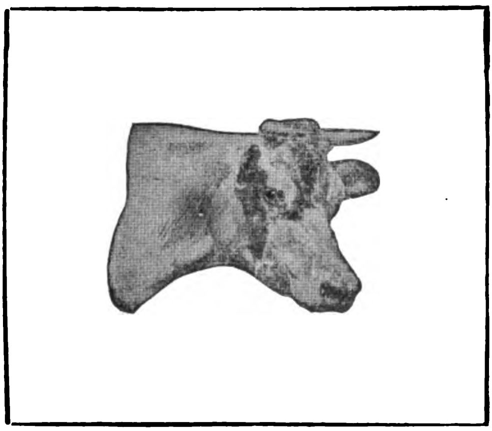
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Veterinary College

BOVINE TUBERCULOSIS.



By VERANUS A. MOORE.

Professor of Comparative Pathology and Bacteriology,

New York State Veterinary College

ITHACA, N. Y.

PUBLISHED BY THE UNIVERSITY.

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BOVINE TUBERCULOSIS

Bovine tuberculosis is one of the oldest diseases of animals of which we have knowledge. It was known to the Israelites in the days of their captivity and from then until now it has been a subject of much thought and investigation. The opinions that have been entertained concerning it have been vacillating, the decrees of one century as to its supposed infectious nature and the use of the flesh of the infected animals often being reversed by those of the following century. History shows that up to the time of the introduction of modern scientific methods for the study of disease, there was little that was definite in our knowledge of tuberculosis beyond the fact that it was a very destructive disease of both men and cattle.

In 1865, tuberculosis was demonstrated to be infectious. In that year, Villemin showed that it could be produced in healthy animals by inoculating them with pieces of tuberculous tissue. His results were confirmed by a number of other investigators. In 1882, Robert Koch discovered the bacillus* (or micro-organism) of tuberculosis and thus completed the already abundant evidence that tuberculosis is a specific, infectious disease. The finding of its specific cause led to many careful and extended investigations into the nature of tuberculosis, the means by which it is spread, and the measures that must be adopted if its spread is to be checked. The results of these numerous inquiries have given us very definite knowledge of the nature of the disease. It is believed that this knowledge, if properly used, will enable every cattle owner to eliminate tuberculosis from his herd, if it is there, and to keep it out, if it is not there.

In order to have a clear understanding of what kind of a disease tuberculosis is, it may be well to compare it with some disease that is generally known and recognized to be infectious. For this we may take diphtheria in children. It is well known that diphtheria is caused by a micro-organism. This organism is known as *Bacillus diphtheriæ*, or sometimes as the Klebs-Lœffler bacillus, from its discoverers. It is also known that when a healthy child is exposed (infected) by being brought in contact with a child sick with diphtheria, the period of incubation (that is, the time elapsing between the exposure and the time the symptoms of the disease appear) is but a few days, and that the duration of the disease is short, lasting but a few days or weeks at the longest. At the end of this short period, the entire course of the disease has been run and the child is either dead or well on the way to recovery.

**Bacteria* (singular *bacterium*) is a general name for "germs" of a vegetable or plant nature. A *bacillus* (plural *bacilli*) is one kind of bacteria, distinguished by being much longer than broad. A *micrococcus* is a spherical bacterium. General terms used to designate many of these minute forms of life are "microbe," "germ," or "micro-organism."

NOTE.—This bulletin is a reprint of Bulletin 225, issued early in 1905, with such changes and additions as are suggested by the increase of knowledge on the subject.

In tuberculosis we have similar conditions, but they differ in detail from those in diphtheria in three very important points,—the length of the period of incubation, the way in which the specific bacteria produce the disease, and the time required for the disease to run its course. With diphtheria the specific bacteria produce a toxin which poisons the system, and this toxin is the cause of death. In tuberculosis, the specific bacteria do not produce such a toxin, but they live in one or more of the tissues of the body, multiply there, and by their increase penetrate deeper and deeper into the organs of the body, destroying the tissues as they go. Finally the injured organs give rise to symptoms, at first slight, but gradually they become more and more serious until death is produced, because some organ necessary for the life of the individual has been destroyed. While diphtheria completes its course in a few days or weeks, tuberculosis requires for the same purpose months and more often years.

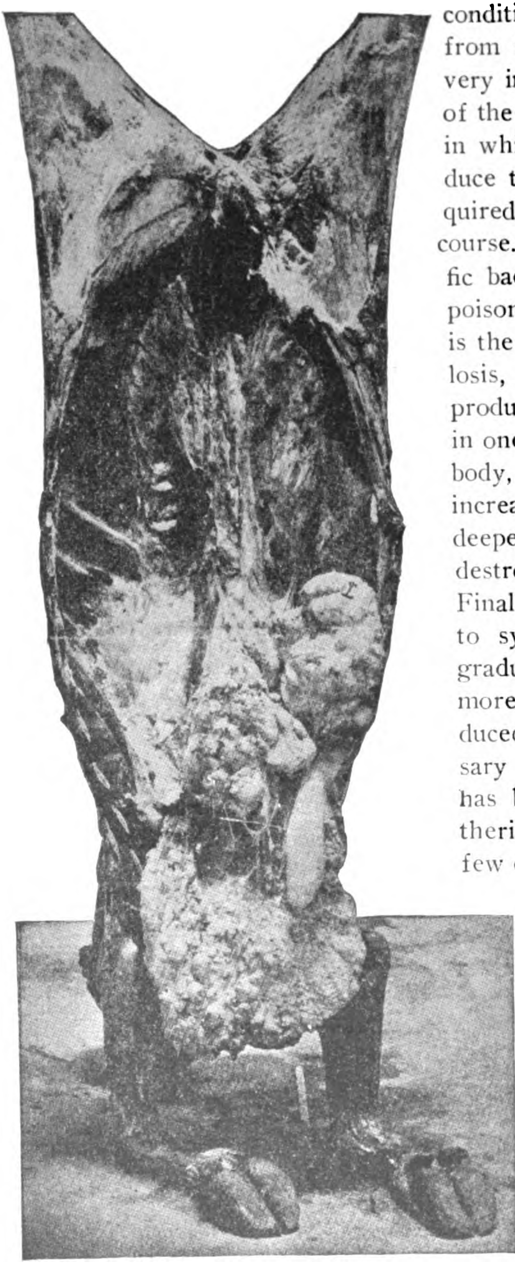

FIG. 128.—*The carcass of an animal killed for beef showing tuberculosis of the liver, omentum and lungs. Generalized tuberculosis (Reynolds).*

It is important that both the specific, and the infectious, nature of bovine tuberculosis should be understood. It is a specific disease because it is produced by a *single* cause—the tubercle bacillus. It is infectious because the tubercle bacteria, the organisms that produce the disease, must first be taken into the

body. This may be accomplished by direct contact of an infected with a healthy animal or by the bacilli being left in a manger, watering-trough, or elsewhere by a diseased individual and later, but before they die, being taken up by a well animal. Thus a barn containing tuberculous cattle will become infected, and healthy animals placed in such a barn before it is properly disinfected are very liable to contract the disease. It is often said, that badly ventilated and poorly kept barns and improper food cause tuberculosis. This is not the case. The disease cannot develop in the absence of the tubercle bacillus, any more than corn can grow in a field in which no corn has been planted. It is, however, undoubtedly true that in poorly ventilated, dirty barns, the tubercle bacilli may be distributed more rapidly than in sanitary stables, but poor air and filth cannot of themselves produce tuberculosis.

In considering, from a practical point of view, an infectious disease like tuberculosis, one must take into account several important features: (1) the *cause*, (2) the *method of infection*, (3) the *period of incubation*, (4) the *duration of the disease*, (5) the *way to detect or diagnose it*, (6) the *way to control it*. There are two other points of interest, namely: (7) *the status of the disease* in the cattle in New York State and (8) the necessity for experimental work in order to learn more about the disease.

1. Cause of tuberculosis.

Tuberculosis is caused by the bacillus of tuberculosis. It is a very small rod-shaped micro-organism. It is so minute that ten thousand of them might be placed end to end within the linear distance of an inch. This organism has a peculiar property of retaining the stain used for coloring it, so that it is possible to distinguish it from other bacteria by a microscopic examination. It will kill guinea pigs when a very few of the bacilli are injected into the subcutaneous tissue. It is also fatal to other animals. The tubercle bacilli that produce tuberculosis in cattle differ very slightly from the bacilli that cause tuberculosis in man, but it is known that they belong to the same species. The Royal Commission on Tuberculosis, appointed by the King of England in 1901, has made interim reports in which it states that it has been unable to find any difference in the disease-producing power of the bacilli from certain human and from bovine sources. Other investigations tend to show that the bovine variety of tubercle bacteria is not found in a very large number of tuberculous people.

This bacillus seems to be able to live for some time in dark and damp places. It is readily killed with a five per cent solution of carbolic acid, or a 1 to 1,000 solution of corrosive sublimate. Sunlight and drying are not favorable to its existence outside of the body.

The tubercle bacilli escape from the diseased animal in the saliva and mucus from the mouth when the lungs or certain glands are discharging

into the *respiratory tract.* It has recently been shown that tubercle bacilli escape in large numbers with the intestinal discharges from many tuberculous cattle. They escape in the pus from tubercular abscesses that open through the skin, and in the milk. It has been shown from all the examinations that have been reported of milk from tuberculous cows, that about fifteen per cent of them give off tubercle bacilli with their milk at some time during the course of the disease. The udders show tuberculosis in about two per cent of the cases.

2. The method of infection.

Animals become infected with tubercle bacilli largely through the digestive tract. The infection by means of inhaling particles of dirt or dust carrying tubercle bacilli, or by getting them into wounds of the skin, is possible but certainly not very common. Healthy cattle "nosing" with infected ones or feeding and drinking after them is the most usual method of contracting the disease. Feeding calves with milk from tuberculous cows is a common means of propagating tuberculosis in a herd. The slow development of the disease makes it possible for calves to be infected and frequently not to show evidence of tuberculosis for many years. I have known of a very large percentage of calves that were fed upon milk of diseased cows to give a good tuberculin reaction (thus showing they were suffering with active infections) before they were six months old. This is believed to be one of the very important ways by which the disease is disseminated in breeding herds.

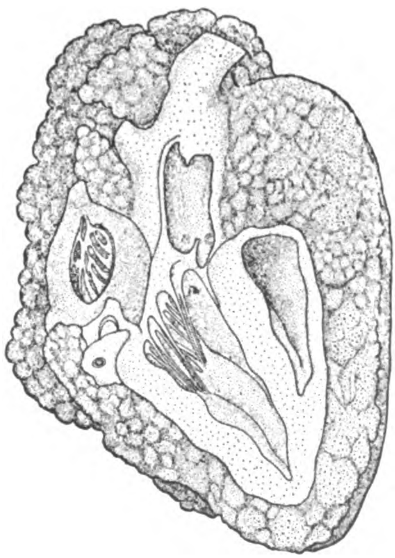

FIG. 129.—*A drawing of the heart of a steer that was killed for beef. The heart muscle is entirely surrounded by a dense mass of tubercular deposit. There were no other lesions found in the animal.*

Tuberculosis is often found in swine fed upon milk from infected cows. In 1903 the writer knew of a carload of hogs that had been purchased in a district where there were many tuberculous cows, and of which the first fifty-nine of them that were slaughtered were all tuberculous. The remainder were not killed at that time. While such a condition may be considered an exception, it is a fact that many swine are infected,

especially when they are fed tuberculous milk. The increase of tuberculosis in hogs is shown by the fact that in 1900, of 23,336,884 hogs that were inspected by the Federal Government, 5,440 were affected sufficiently to cause a condemnation of some one or more parts of the carcass; in 1905, of 25,357,425 hogs inspected post-mortem 46,919 carcasses and 142,105 parts of carcasses were condemned for tuberculosis.

It should be remembered that the greater the percentage of tuberculous cows in the herd, and the further advanced the disease in the cattle, the greater the danger of infection from the use of the milk. In cases where the disease is restricted to small nodules in the lymphatic glands, or perhaps in the lungs, the danger of tubercle bacilli being in the milk is very slight, but when the udder is tuberculous they are con-

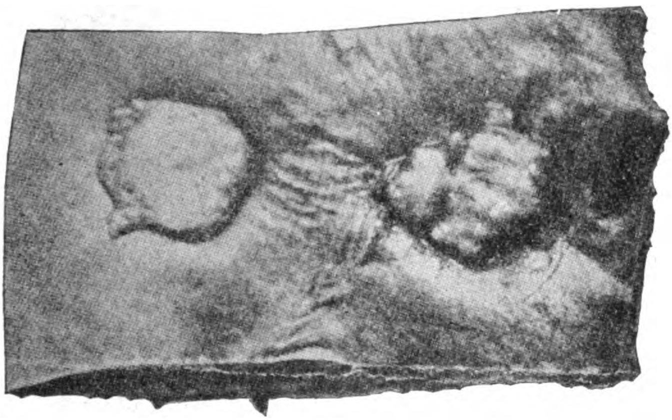

FIG. 130.— *Liver of a cow showing two small tuberculous deposits. They were the only lesions found. The cow gave a typical tuberculin reaction. Natural size.*

stantly present in the milk and often in very large numbers. When calves or pigs are fed with milk of this kind they are almost sure to be infected. The same result may follow when it is fed to children or adults.

Practically the only way tuberculosis gets into a herd of healthy cattle is by the introduction of a tuberculous animal or animals. It has often happened that farmers who have perfectly healthy animals buy a nice looking cow that is tuberculous, although the disease was not at all in evidence, and sooner or later this animal infects a very large number of individuals in the herd into which it is brought. *The buying of infected animals and the feeding of calves with infected milk are largely responsible for the spread of tuberculosis in cattle.*

The history of tuberculosis in cattle shows that when it is once introduced into a previously uninfected district its tendency is to spread from farm to farm with a rapidity which depends upon the activity of the cattle

traffic. If the interchange of animals between herds is frequent the disease usually spreads rapidly. If, on the contrary, there is but little interchange of animals, tuberculosis spreads slowly in a newly infected community. This observation relates to the spread among herds; other conditions govern the spread of tuberculosis in the herd after infected animals are added. The latter factor is controlled by the degree of contact between the diseased animals and their associates, and the sanitary and other conditions to which the herd is subjected. The increase in the

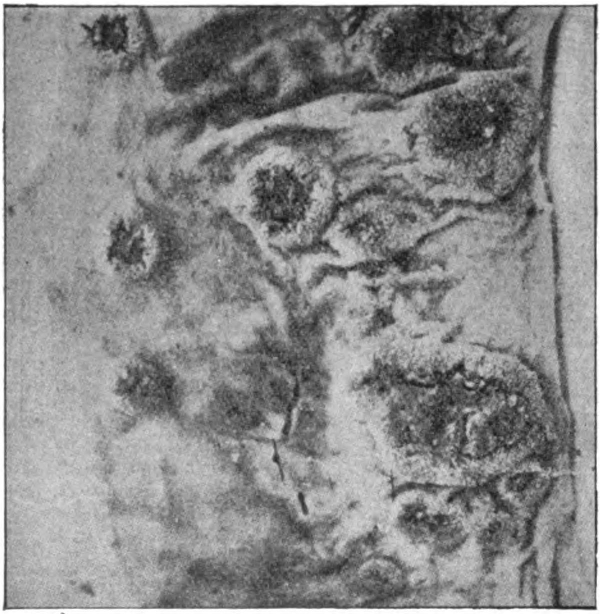

FIG. 131.— *Tuberculous ulcers in the intestines of a cow. These are not common in cattle. There are many worm nodules on the intestines that are frequently mistaken for tuberculous nodules.*

cattle traffic is one reason why there is more danger of spreading tuberculosis now than there was a generation ago.

If a tuberculous cow is placed in confinement with other cattle, she will convey the disease to them more certainly and more quickly than when the animals are at liberty. As bearing upon this point, it has been noted repeatedly that tuberculosis spreads more rapidly in herds when they are confined in winter than when they are at pasture in summer, and there is reason to believe that this difference is due, not to the season, but to the intimacy of contact. Moreover, tuberculosis once introduced spreads with increasing rapidity as the centers of infection are multiplied. So long as there is but one infected herd from which it can spread in a district,

the extending of the disease will necessarily be slow, but when ten herds are infected from this one the progress of the disease will be ten times as rapid, and when five herds are infected from each of the ten, the disease will, other factors being equal, spread at fifty times the original rate of progress.

3. Period of incubation.

In case of many of the infectious diseases, the time that elapses between the exposure (infection) of the individual and the time when the disease appears is short and more or less uniform. This makes it possible to quarantine suspected animals until after this period has passed and thus ensure safety in placing them with the home stock. With tuberculosis this period is not regular and it is not known how long it may be. Our present knowledge of the subject shows that it varies from a few days to as many months. *Tuberculin* (see page 115) *does not give a reaction during this period.* It is necessary, therefore, for safety that cattle which do not react when purchased should be tested again in from three to six months, as it is possible they were bought after they had become infected but in the period of incubation. This precaution is of *great importance in protecting a dairy.* The newly purchased cows should, if possible, be kept apart from the herd until after the second test.

4. The duration of the disease.

Tuberculosis is a disease of very slow progress. It often requires years for it to destroy its victim. The tubercle bacilli multiply and penetrate into the organ to which they were first carried and gradually destroy it. It often happens that the tubercle germs pass into the blood or lymph and are carried to other parts of the body where each germ may start a new tubercle. This is the condition known as generalized tuberculosis. If general and acute, running a rapid course, it is called "miliary tuberculosis" or "quick consumption." Fig. 129 illustrates a case of chronic generalized tuberculosis.

When the diseased tissues are restricted to one organ, the condition is known as localized tuberculosis (Fig. 130). When the organs in two of the cavities, such as the lungs in the pleural cavity, and the liver in the abdominal cavity, are affected the condition is known as generalized tuberculosis. This is very important, as the meat inspection regulations of this and other countries permit the flesh of animals suffering from local tuberculosis to be used for food but when the disease is generalized it must not be so used.*

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* Following are the United States regulations concerning the use of flesh of tuberculous animals:

"Generalized" tuberculosis refers to that form of the disease in which the bacilli have been disseminated through the blood and lymph, and in which a number of organs are affected. "Extensive" tuberculosis refers entirely to the

When the disease is local, it often requires a very long time for it to invade the organs sufficiently to cause the death of the animal. It may happen that the germs of the disease are lodged in some organ, like a lymphatic gland, that is not absolutely necessary for the life of the animal and the entire organ may be destroyed without apparent injury to the individual. If the diseased process is arrested before it has advanced too far, even when it is in a vital organ, such as a lung, the liver, or the kidney, the animal will continue to appear to be perfectly sound. Animals thus affected are thought to be perfectly well, as they appear to be, but sooner or later the disease becomes more extensive. It often happens that the disease becomes arrested or temporarily healed, and remains so for a considerable time, one, two or three years and even longer, when it may start up again. Frequently, animals that are in a period of incubation or that contain foci of arrested disease and which appear to be perfectly well, are bought in good faith and placed in a healthy herd with the result that they bring the disease and not infrequently transmit it to other animals. Various manifestations of the disease are seen in Figs. 129–132.

It is very likely that some animals, especially cattle, are infected and recover. This is to be expected in some cases where they are kept under favorable hygienic conditions. At present, however, our knowledge of recovery from tuberculosis in cattle is too meagre to warrant much encouragement from this source. It is safer and more economical not to trust to a recovery. An animal that once reacts must be considered suspicious thereafter. However, a few such animals remain well until they die from other causes.

5. How to detect tuberculosis in cattle.

From what has been said about the course of the disease, it is perfectly clear that there may be a large number of animals in a herd that are

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amount of tuberculous matter and the number of tubercles, and may apply to a case which is confined to one of the body cavities.

(1) The carcass may be passed when the lesions are limited to one group of lymphatic glands or one other organ.

(2) The carcass may be passed when the lesions are limited to two groups of visceral lymphatic glands in either the thoracic or the abdominal cavity.

(3) The carcass may be passed when the lesions are limited to two visceral organs (other than lymphatic glands) in the thoracic or the abdominal cavity, provided the lesions are slight, calcified, and encapsulated.

(4) The carcass may be passed when the lesions are limited to one group of visceral lymphatic glands and one other organ in the thoracic or abdominal cavity, provided the lesions in the affected organs are slight.

(5) The carcass may be passed when the lesions are confined to two groups of visceral lymphatic glands and one other organ in the thoracic or the abdominal cavity, provided the lesions are slight, calcified, and encapsulated.

(6) The carcass may be passed when the lesions are confined to the lungs, the cervical lymphatic glands, and one group of the visceral lymphatic glands of the thoracic cavity, provided the affection is slight and the lesions are calcified and encapsulated.

(7) The carcass shall be condemned when well-marked lesions are discovered in both the thoracic and the abdominal cavity.

infected with tuberculosis but which appear to be sound. There may be others in which the disease is far advanced and the animals show that they are affected. There are two ways by which the disease can be detected, namely, by a physical examination and with tuberculin.

The physical examination is of value in advanced cases only, or when the diseased part is in evidence, as for example in the lymphatic glands of the head. Experience has shown that by this method one is unable to find more than a very small percentage of the animals that are tuberculous and a menace to the healthy cattle. This method, therefore, is a very crude one and cannot be trusted except in the very advanced cases and in those in which the early stages of the disease are in evidence externally.

The tuberculin test is far more reliable. There have been many unjust things said about tuberculin and many cattle owners have come to fear that it is a dangerous agent to use. Much of this fear came from statements made regarding its possible ability to stimulate latent nodules. The work of the last ten years has not confirmed the earlier opinions but to the contrary it has shown that tuberculin in proper doses is as harmless as need be to the health of the cattle. The dangers that are supposed to come from it are the results of poor tuberculin, unclean instruments, carelessness, or other avoidable causes.

Tuberculin. Tuberculin is the liquid, usually glycerinated bouillon, on which the tubercle bacilli have multiplied or grown. It is concentrated after heating and removing the bacteria and a little carbolic acid or thymol is added to preserve it. The active principle of tuberculin is a substance resulting from the multiplication and maceration of the tubercle bacilli in the liquid. In its preparation it is necessary that the tubercle bacilli "grow" sufficiently, which usually requires several weeks before the liquid is used. The flasks containing "cultures" as they are called, are, when ready, heated for some time at the boiling point. The liquid is then filtered to remove the bacilli, the fluid is then concentrated over a water bath. It is again filtered through a porcelain filter and stored. It will be noticed, that tuberculin is heated at two different times during its preparation sufficiently to kill the tubercle bacilli and it is also filtered through a substance that would remove the tubercle bacilli, if any escaped the first filtration. When ready for use tuberculin is a clear, amber colored liquid. The intensity of its color varies according to the amount of blood pigment in the meat from which the bouillon was made.

Tuberculin cannot possibly produce tuberculosis, because it does not contain any tubercle bacteria. *There is no evidence that in cattle it excites a latent tubercle into activity, or that it tends to make the disease worse. It is used the world over and as yet no authentic report of injury caused by its use has been recorded.* It has been used in the treatment of tuberculosis in man and there are several physicians who have reported favor-

FIG. 132.—*A photograph showing the tubercular deposits on the pleurai surface covering the ribs of an advanced case of generalized tuberculosis (Reynolds).*

able results with it. All those who have worked with tuberculin are agreed that it is one of the safest and surest tests in detecting the presence of active tuberculosis that is known to the medical world. All are agreed, however, that it must be *properly used,* and that all those physical conditions that would tend to interfere with it must be avoided. If in its use these precautions are taken, tuberculin is as sure as any reagent.

If the animal is sound when tuberculin is injected, no reaction is observed. If, however, the animal contains an *active* tubercle there is a reaction which shows itself in a rise of the temperature beginning from six to sixteen hours after the injection and continuing for from six to ten hours and possibly longer. Fig. 134 shows the curve of the temperature reaction after injecting the tuberculin in a tuberculous animal. There is in some cases a general depression in the appearance of the animal in addition to its elevations of temperature.

The interpretation of the temperature record requires care. If, however, all conditions pertaining to the protection of the animal have been fulfilled, the temperature curve mentioned is a very sure indication that the animal is suffering from an active, although it may be a very small, tuberculous growth. A good reaction will take place when the active tubercle is so small that it is difficult to see it. The so-called failures to find the disease after the reaction have been due in many cases to the fact that the bone marrow, brain and inter-muscular tissue were not carefully examined. Small lesions in the lymph glands are also easily overlooked. If there is no reaction the correct interpretation is more difficult. In this case there are three conditions which must be taken into account, namely:

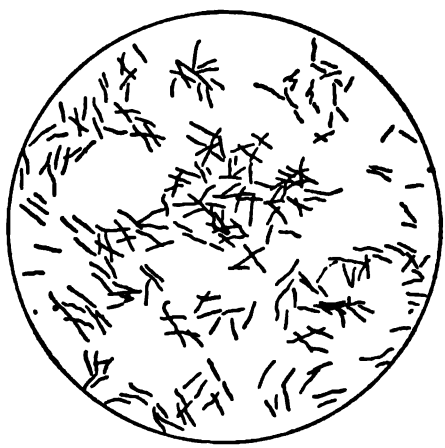

FIG. 133.—*The germs or bacilli that cause tuberculosis. Much magnified.*

(1) If the animal is extensively diseased, it may not react. In this case the physical condition would show that the animal was at least not healthy. There are a number of cases on record where the tuberculin was accused of failing to react when the disease present was not tuberculosis at all but actinomycosis, fungous diseases, or other disorders resembling somewhat in appearance a tuberculous condition.

(2) If the test was made during the period of incubation there would be no reaction although the disease may soon develop. To overcome this danger, a subsequent test should be made in from three to six months.

(3) It is known that cows that have reacted, may, because of the arrest of the disease, fail to react subsequently but still later the disease may start up again, when the animal will react. We have records of many cases of this kind. Great care must be exercised, therefore, in the interpretation of *negative* results, especially of tests made in herds where tuberculosis exists, and where it is possible that the animals failing to react have already been infected.

In applying the present knowledge of tuberculosis to the purchase or exchange of cattle on the tuberculin test, it is safe to consider animals that react to be suffering with active tuberculosis; but if they do not react they must not be considered to be absolutely free from infection, especially if they are taken from a herd in which tuberculosis exists. The longer the disease has been in a herd and the larger the number of animals that are infected, the greater are the chances that those which fail to respond will react if tested at a later date, from the fact that tuberculosis which has become latent or healed may "break out" or become active again, or because the animals have been infected but have not yet developed the disease. For example, a few years ago a large herd was tested and many of the animals reacted. Those that did not react were placed in a new barn and after three months they were retested and several of them responded. Three months later a few more reacted. These later tests discovered the individual animals that were infected but in the period of incubation, or those in which the disease was temporarily arrested at the time of the first test. When there are very few reactions at the first examination, the subsequent ones are usually negative. Tubercle bacilli in a herd of cattle are much like weeds in a garden,— the more there are at the time of the first weeding the more there are liable to be at the second cleaning. When most of the animals in a herd respond to the test, all the others must be regarded with suspicion. When only a few in any herd respond, it is less likely that any of the remainder are infected.

In a herd where the Bang method was being carried out, the retest of the animals that reacted gave a negative result in about 20 per cent of the cases. Some of these continued not to react for one, some for two and others for three years; but the greater number reacted again after one or more negative tests. These facts are convincing that animals which react once to tuberculin should not be considered safe to return to the sound herd, although some of them may recover.

The subsequent reactions and non-reactions are often difficult to understand by those not versed in the nature of tuberculosis. They are, however, not more mysterious than many other phenomena. They are in perfect harmony with the natural course of the disease. Tuberculosis is the result of little organisms living on the tissues

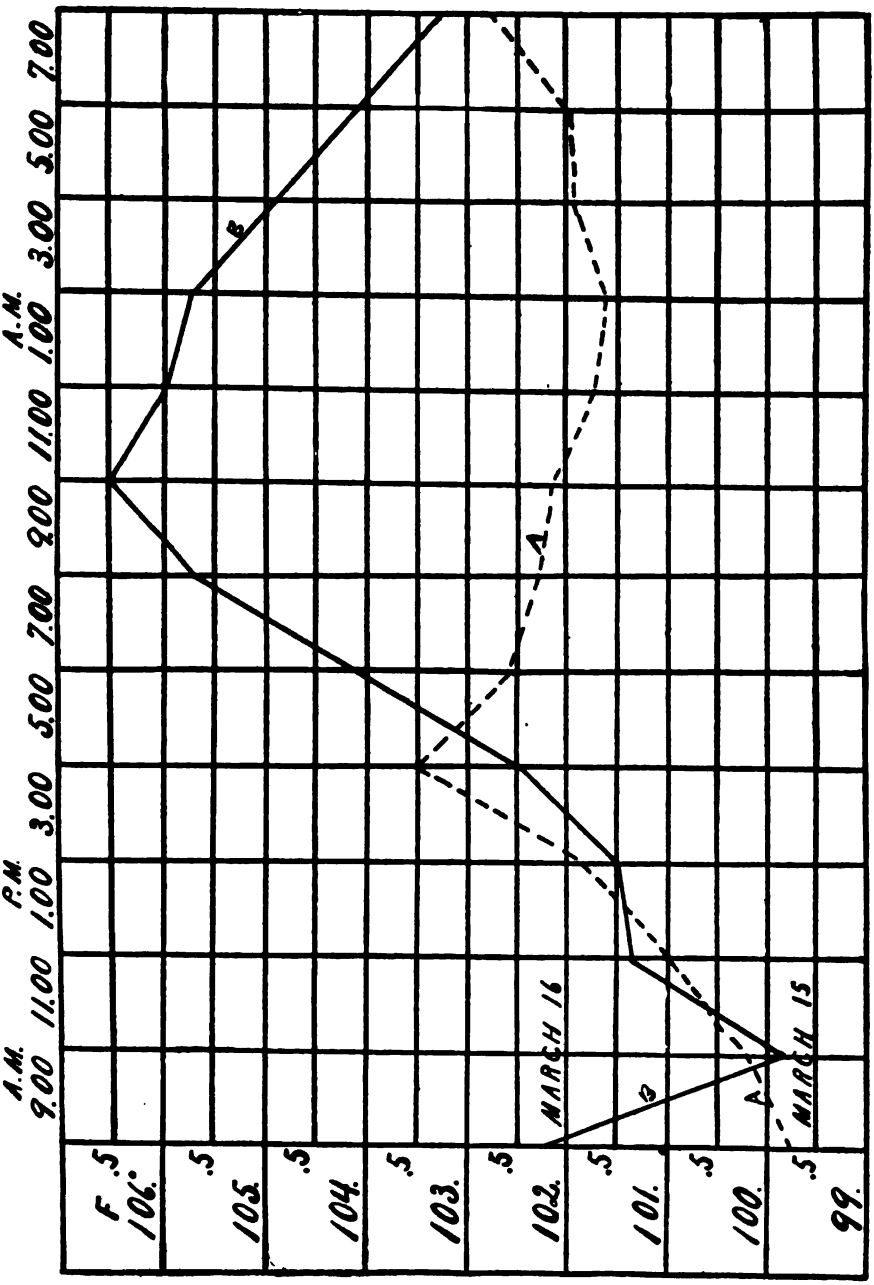

FIG. 134.—*Temperature curves. The dotted line "A" represents the temperature of a cow for 24 hours before injection of tuberculin. The solid line "B" represents the temperature for 24 hours after the injection of tuberculin showing the tuberculin reaction between 4 P. M. and 7 A. M.*

of the animals, and whether they multiply continuously or become checked in their activities depends upon the degree of the resisting force of the animal and possibly the invading ability of the organisms. It is a struggle between two opposing living forces, and sometimes one and sometimes the other is in the lead. When this parasitic nature of tuberculosis is understood, there will be less difficulty in comprehending many of the seemingly contradictory manifestations. It is the neglect of these natural but subtle tendencies and powers of tubercle bacteria that has enabled them to make headway and gain entrance to the tissues of cattle when the owners have thought they were very careful to guard against them. For example, after a herd has been tested and the reacting animals destroyed, it is possible that no further attention has been given to the remaining cattle, some one or more of which may later develop the disease and spread it to the other animals in the herd. This unfortunate condition is not the fault of the first test, but of the failure to make subsequent ones. The purpose must be to avoid the possibility of infection.

6. The control of tuberculosis.

The real problems relating to tuberculosis before the cattle owners are the prevention and the eradication of this disease. They resolve themselves into the best methods to follow under two distinctly different conditions, namely: (1) when the herd is free from tuberculosis, and (2) when a greater or less number of animals are already affected.

The protection of healthy herds.

In preventing the entrance of a specific disease, it is simply necessary to keep out the microbe that produces it. The important question to consider in this connection is, how to keep it out. I have already mentioned the two most common channels that are known through which tubercle bacteria gain entrance to a herd of uninfected cattle, namely, (1) through the feeding of calves with the unsterilized milk from creameries and possibly the whey from cheese factories where the milk from tuberculous cows is received, and (2) the introduction into the herd of a tuberculous animal or animals. The prevention by cutting off these channels of infection is not difficult nor expensive compared with the elimination of the disease if introduced or the loss it will occasion if allowed to remain.

To guard against the first it is necessary to sterilize the milk fed to calves, unless it is known that the animals from which it came are free from the disease.

To avoid the second danger, it is necessary to have all the animals carefully examined and tested with tuberculin before bringing them into the herd. The tuberculin should be applied by a competent person who

appreciates the necessity of complying with every precaution necessary for obtaining the correct results of the test. If the cows come from a tuberculous herd they should be retested in a few months. Russell has pointed out the great danger of buying cows from infected herds without the proper use of tuberculin.

The handling of tuberculous herds.

In herds in which the disease already exists to a greater or less extent, the problem is far more difficult. The diseased animals sooner or later become a source of expense and loss rather than profit. The danger of spreading the infection to calves, swine and possibly children by the use of infected milk is too great to take chances with tuberculous cows. The loss of valuable strains of animals and the stigma of having a diseased herd are further reasons for eliminating the disease. It is clear that a dairyman cannot afford to have tuberculous cows in his herd.* The question is, how can a man who has such a herd eliminate the disease with the minimum loss?

There are at least three procedures to choose from: (1) The total destruction of the infected animals; (2) their slaughter for beef under proper inspection, procuring the meat value of those that are only slightly infected; (3) the application of the Bang method.

(1) *The slaughter of infected animals.* The plan of total destruction (except for fertilizer purposes) is based on the assumption of State aid for at least partial compensation of the owner. This method has not proved entirely satisfactory because of lack of appropriation to pay for the cattle and, further, because it calls for an unwarranted destruction of property in cases of animals suitable for beef that are found upon post-mortem to be *only very slightly* diseased. In many herds where a large number of animals react and where the infection has not been of long standing, a very large percentage of the cattle have a beef value, but the few badly diseased animals have no value and their destruction is the most economic disposition to make of them. If the herd has been infected for a *long time,* a large percentage of the animals are liable to be suffering with advanced generalized tuberculosis.

(2) *Utilizing slightly infected animals for beef.* The plan of using the

*Tuberculosis destroys by death a certain number of animals after the disease has become established in a herd.

Tuberculosis causes a waste of food by feeding it to animals that are diseased and cannot give an adequate return.

Tuberculosis causes heavy losses by infecting other animals, such as swine, calves and adult cattle through the milk and by contact. The enormous annual lost from tuberculosis in swine illustrates the latter point.

Tuberculosis reduces the productive and market value of the cows. As soon as there is physical evidence of its existence the animals have practically no market value.

Tuberculosis destroys the good reputation of a herd, which renders it difficult to sell the animals and often to dispose of their products.

carcasses for beef if they pass inspection, is in harmony with the Federal meat inspection service and also with the meat inspection regulations of other countries. Large numbers of animals affected with localized tuberculosis are passed for food annually by our government inspectors. In Germany the meat of more extensively tuberculous animals is *sterilized* and then sold for food at a lower price.

The Wisconsin law permits the Live Stock Sanitary Board to sell reacting animals to slaughter-houses having a Federal inspection. By this method thousands of dollars are saved annually by the State toward the payment for the reacting animals from the moneys received for cattle that pass the inspection. It is hoped that our legislature will provide for the economic disposition of animals that are slightly infected with tuberculosis. The Board of Health regulations in many places prohibit the sale of meat from infected animals, no matter how slight the infection and yet they do not provide for a meat inspection. This excludes the legal use for food of animals that react to tuberculin though in good condition, but it does not prohibit the sale of animals not known to be infected at the time of slaughter. This leaves the passing on the unwholesomeness of the carcass to the butcher, who is interested financially and who is not skilled in the diseases of animals. It is equitable to give the small owner the same privilege of disposing of his animal or animals that is accorded the large packers who have government inspection. The State of Pennsylvania has state inspectors who examine the carcasses of cattle that are slaughtered for beef after the tuberculin test, when they are killed in local slaughter houses. This protects the people and affords an exit for the slightly infected animals.

(3) *The Bang method.* The Bang method for handling tuberculosis is the procedure recommended and carried into effect in Denmark by Professor Bang of the Copenhagen Veterinary College.*

The object of this method is to replenish a tuberculous herd with as little loss as possible. It requires that all animals that show physical symptoms of the disease shall be destroyed. Those which give a tuberculin reaction but which exhibit no evidence on physical examination of their being tuberculous, are isolated. They are kept for breeding purposes. The reacting animals are carefully watched and if any of them develop obvious symptoms of the disease they are slaughtered. The stables from which the diseased animals are removed are thoroughly disinfected.

The method as originally proposed has been modified from time to time in accord with increased knowledge of the disease and the conditions under which it exists. Its success lies in the fact that it conforms to

* Bang, B. The struggle with tuberculosis in Denmark. The Veterinarian, Vol. LXVII (1895), p. 688.
Bang, B. Tuberculosis of cattle. Penn. Dept. Agri., Appendix Bull. 75, 1901.

the chronic nature of the disease and its tendency to become arrested. The large percentage (35.4 per cent) of dairy cows in Denmark that reacted to tuberculin, suggested the importance of replenishing the herds with healthy cows before the total destruction of the reacting ones. The method is summarized in the following statements:

1. A herd is tested with tuberculin. The animals that are in a bad condition are slaughtered. The reacting animals that show no physical evidence of the disease are isolated. They are kept for breeding purposes.

2. The offspring from the reacting cows are promptly removed from their dams and fed milk from non-reacting cows, or the pasteurized (heated to a temperature of 85° C. or 185° F.) milk from the reacting ones. The milk of the isolated cows after pasteurization is also used for human food.

3. If any of the isolated cattle give evidence of the disease advancing, such as enlarged glands or emaciation, they are slaughtered.

4. The non-reacting animals are tested from time to time, and if any individuals react they are placed with the isolated ones.

5. The calves that are raised from the reacting cows and which fail to react to tuberculin, are placed in the sound herd.

It is important to test, with tuberculin, calves that have been born of tuberculous dams and raised on pasteurized milk of tuberculous cows for the reason that it is possible through inadvertent accidents that some of them have become infected. In my observations in various herds, from one to four per cent of the calves brought up under these conditions have reacted to tuberculin at six months of age, but very rarely after that if proper precautions are taken.

As the sound herd is replenished, the isolated cattle may be fattened and killed, under proper inspection, for beef (See page 273). In this way the people of Denmark have been able greatly to reduce the very high percentage of tuberculous cattle and at the same time to minimize the loss they previously sustained by the death of diseased animals.

The Bang method, modified to suit the local conditions, has been applied with great success in Hungary, where the reports show that many highly infected herds have been freed of the disease in from four to six years. In Norway and Sweden, the results have been equally good. Professor Regner* states that the percentage of reacting animals among 36,149 cattle was, at the beginning of the application of this method, 33.6 per cent. After a period of two to nine years, in different herds, it has been reduced to 4.7 per cent.

This method has been applied with success at the Wisconsin Agri-

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*Regner, Gustav. The suppression of tuberculosis among domesticated animals. Eighth International Veterinary Congress, Budapest. Sept., 1905.

cultural Experiment Station,* at the New York Agricultural Experiment Station (Geneva) † and by several private cattle owners. The Hon. W. E. Edwards, of Rockland, Ontario, Canada, used it in the handling of his valuable herd. In 1903, at the meeting of the American Veterinary Medical Association, he read a forceful paper‡ on his experience with the method, a few lines of which I quote: "The question arises, can tuberculosis, one of the most constant diseases present in our animals, be eradicated? My answer is, yes, most emphatically. I am fully convinced of the reasonable possibility of the eradication of tuberculosis from our herds and of the maintenance of sound herds."

It is not the purpose of the Bang method to return to the sound herd animals that have reacted, but which, after a period of one or more years, fail to react. Experience has shown that a variable number of reacting animals will remain apparently in a sound condition. The method has two redeeming features: first, it requires the elimination of cattle that have no real value because of the advanced stage of the disease; and, secondly, it enables the owner to obtain the actual worth of the others. Its success has been possible because of the great value of tuberculin in detecting the infected animals that still appear to be in perfect health and in which the disease has just begun.

The success that has come from the application of the Bang method, in Europe and in many herds in this country, warrants its recommendation to those who have valuable animals infected. There may be modifications and changes necessary to make it fit the conditions, but these are in harmony with the procedure. Professor Bang encountered much tuberculosis in the cattle of Denmark, and by the persistent application of conservative methods the disease has been reduced in a few years to such an extent that it is no longer a burden or a menace to the people.

Although the law in this State is based on the theory of eradication by slaughter of infected animals, the Commissioner of Agriculture is willing to allow any owner of a tuberculous herd tested by the State to adopt the Bang method instead of having the reacting animals destroyed. This is of great value, especially to the owners of valuable herds.

In the control of tuberculosis, it is well not to forget that it is a personal matter, and that prompt and active efforts to eliminate the disease should be put forth by all those who have infected herds. Each man should be master over the diseases that may threaten his herd.

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*Russell, H. L. The history of a tuberculous herd of cows. Wis. Agr. Exp. Sta., Bull. 78, 1899.

†Harding, H. A.; Smith, G. A.; Moore, V. A. The Bang method of controlling tuberculosis, with an illustration of its application. Bull. No. 277. N. Y. Agr. Exp. Sta., Geneva, N. Y., 1896.

‡Edwards, Hon. W. E. The Bang system for the eradication of tuberculosis in cattle. Proceedings of the Am. Vet. Med. Asso. 1903, p. 124.

Some principles to be observed in the elimination of bovine tuberculosis.

If tuberculosis is not allowed to spread to uninfected animals and the infected ones are disposed of as promptly as possible, tuberculosis will soon disappear. In facing the discouragements of finding tuberculosis in his herd, the dairyman should consider these conditions:

1. There are some cattle suffering with advanced tuberculosis. These are of no value, but a menace to the health of the herd and consequently should, for economic reasons, be promptly destroyed.

2. There are many infected, though but slightly diseased animals, that are poor milk producers but which do have a good beef value.

3. There are presumably many valuable strains of cows and many high bred animals that are infected though but slightly diseased. The value of these animals is in their offspring quite as much or more than in their milk production. The Bang method affords a means for preserving these animals and procuring their offspring without danger to others.

4. There are large numbers of uninfected herds, and many cows in the infected ones, that should be *carefully protected* from infection.

5. Tuberculosis can not spread unless the bacteria that produce it are brought by some means to the uninfected animals. They are most commonly carried by infected individuals or their products.

Practical procedure.— As it is to the advantage of every cattle owner to have a sound herd, the greatest progress will be made in the eradication of tuberculosis when the greatest number of owners take up the work of elimination for themselves with the aid of competent veterinary advice. The first steps to be observed in the procedure against tuberculosis may be summarized as follows:

1. Promptly eliminate from the herd all animals that have tuberculous udders or that give evidence of being tuberculous. This will greatly reduce the danger from the milk.

2. As soon as possible, have the tuberculin test applied to all the remaining animals to ascertain which individuals are infected. These are the ones that are still dangerous to the herd.

3. Separate the well animals from the infected animals. When the reactors are pointed out, the most economic method of dealing with them must be determined from the local conditions.

4. The stables is which the diseased cattle were kept should be thoroughly disinfected.

5. The non-reacting animals should be tested every six months until all those previously infected are detected and removed. This will leave a sound herd which will remain so if properly protected.

6. In buying cattle, great care is necessary not to bring infected animals into the sound herd. They should be carefully tested with tuberculin, and retested in three to six months and all reactors removed.

7. It may be found desirable, in order to replenish the herd with sound animals, to modify present methods and raise more calves and to add a smaller number of cows by purchase. The first purpose is to obtain a sound herd, and it may be possible that the quickest and cheapest method will be to raise it.

The demand for the eradication of all reacting animals arises very largely from the common opinion that tuberculosis is freely transmissible from animals to man. The question is less one of danger to human beings than of menace to the cattle industry, although, of course, its relation to public health should not by any means be overlooked.

7. The status of bovine tuberculosis in New York.

In dealing with a great problem, it is desirable to know as many facts about it as possible. There are those who feel that there is a large amount of tuberculosis in our cattle and others who say there is not. The unrestricted entrance until recently of dairy cattle from without and a lack of rigid precautionary measures in the interchange of animals within the State, have caused much concern relative to its effect upon the spread of tuberculosis in the cattle of the State. It cannot be denied that such methods have afforded abundant facilities for the dissemination of tubercle bacteria.

In order to determine the extent to which the disease has spread, I have collected and compiled the results of a number of tests that have been made during the last two or three years, but largely in 1907, by a considerable number of veterinarians to whom this College furnishes tuberculin. The results show that of 421 herds tested, 302 contained reacting animals. These herds contained a total of 9,633 animals, of which 3,432 reacted. They were distributed in 39 counties. The greater number of the tests were made for one or the other of three different reasons, namely, (1) when the herd was suspected of being diseased, (2) when the purchasers of animals required the test before accepting the cattle and (3) when the purchasers of the milk or its products required that they come from healthy cows.

The official tests by the State Department of Agriculture for the years 1904–6 inclusive, kindly furnished me by Dr. Kelly, include 262 herds with a total of 3,088 animals, of which 673 reacted. They were distributed in 50 counties. These herds all came under the operation of the law. Infected animals were found in 121 herds.

The reliable available data, therefore, are restricted to the testing of 683 herds, aggregating 12,721 animals. The animals were distributed in fifty counties. Of the 683 herds, 423 contained reacting animals. A very small percentage of the animals showed physical symptoms of the disease. Although these figures show a somewhat extensive infection of

the herds examined, it must be remembered that they represent only about one-half of one per cent of the cattle in the State.* It is clear that general deductions should not be drawn from the condition found in so small a percentage of animals. The conclusion, however, seems to be well founded that tubercle bacteria have improved their opportunity and have become quite widely distributed in our cattle.

The insidious nature of tuberculosis and the exceptional opportunities afforded for its spread, are largely responsible for the extent of the disease. If there is more tuberculosis in the cattle of one locality than there is in another, it is because the opportunities for its spread have been better. Every case must have been contracted in some manner from a previous one. Unfortunately, the subtle nature of this affection has not been sufficiently understood by many to enable them to recognize the facts concerning it. As a consequence, many dairymen have neglected to take precautions to protect their herds. As knowledge of the means of dissemination and the course of tuberculosis itself in the body of the infected animal increases, it is made clear that many of the efforts that have been put forth to prevent it have not succeeded because they failed to prevent the entrance of tubercle bacteria. The knowledge derived from the application of the Bang method, the opportunities for repeated and frequent tests and autopsy, have brought out many very important facts relating to the course of this great scourge of cattle, and there is no longer any reason for mere guessing or for hopeful neglect.

Although bovine tuberculosis seems to be irrepressible, it is not such an unconquerable enemy as it may appear. If we stop its spread it must disappear with the present infected animals. There are in addition many decided improvements. The most important of these are: (1) the enforcement of the law to prevent dairy cattle from coming into the State unless they pass the tuberculin test, (2) the privilege granted by the Department of Agriculture to owners of herds to apply the Bang method, and (3) the increased interest taken by cattle owners to protect their herds and to weed out the diseased individuals. The last is evidenced by the increased demand for tuberculin from the State Veterinary College. In 1903, there were 3,867 doses called for by veterinarians and the State Department of Agriculture; 7,605 doses in 1904; 7,985 doses in 1905; 13,038 doses in 1906; and 25,197 doses in 1907 were thus distributed. With this widespread interest on the part of the farmers themselves and a better knowledge of the nature of the disease and its methods of control by the practicing veterinarians, there is every reason to believe that the healthy herds will be better protected and that one

*The year book of the U. S. Department of Agriculture for 1906 gives New York 1,826,211 milch cows and 944,734 other cattle.

after another of the infected ones will be replaced with sound animals. The goal toward which all are working is the eradication of bovine tuberculosis as quickly as possible.

8. Necessity of field experiments for the study of animal diseases.

A careful review of our present knowledge of bovine tuberculosis shows that, while we have many important facts concerning it, we still need further information. This information can come only from actual investigation on a considerable number of animals living under what might be considered normal conditions. In order to know the best, or at least the most economical, method of dealing with tuberculin-reacting animals we need to have more knowledge concerning the recovery of the slightly affected individuals and the conditions of the diseased processes in the cases that fail to react on the second test. We have very definite knowledge as to the means of dissemination and the channels of infection, the course of the disease in the beginning and in the fatal cases, but much additional knowledge of the course of the disease in the arrested cases that appear to recover is needed; and much experimental knowledge must be acquired concerning the best methods of handling such animals with safety to themselves and to others. Vaccination or immunization of cattle against tuberculosis is now being strongly advocated, but before our cattle owners accept such recommendations they should be assured by carefully conducted experiments that the methods are genuine and that the results will be satisfactory.

The millions of dollars invested in cattle in New York State and the importance of the cattle industry to the general welfare of the State, demand that no effort should be spared to secure the most perfect knowledge of tuberculosis and also of other infectious and communicable animal diseases. From the very nature of the case this information cannot be forthcoming without ample opportunities for investigation. We must supplement the laboratory and stable work with actual field work on a farm or farms that are devoted to these particular purposes.

VERANUS A. MOORE.

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CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Plant Biology

PLANT-BREEDING
FOR FARMERS

By H. J. WEBBER

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PLANT-BREEDING FOR FARMERS

It is the writer's object in this bulletin to discuss those methods of plant-breeding that are simple and suitable for the general use of farmers. The rapidly accumulating evidence points every day more and more strongly to the great practical importance of this subject. The experimenter may study and elucidate the methods of breeding and demonstrate what can be accomplished; the specialist may breed many new types of value, but what is required to produce the greatest good is the adoption of the methods of selection in the farm practice pursued by the farmers generally. In the newspapers, the agricultural press and experiment station bulletins we see considerable discussion of plant-breeding, some of it unfortunately of rather sensational nature and possibly of questionable value. We might form the idea from this, that everything possible is being done and that there is no chance for a farmer to accomplish anything of value. This would be a mistaken idea. The workers in this field at the present time are just skimming the surface, jumping from knoll to knoll on the mountain tops, while the fertile valleys remain yet unexplored. Instead of a few specialists and scientific men working here and there, the farmers the country over, should be informed on the subject of breeding and introduce into their general farm methods, systematic breeding in the production of their planting seed. The evidence strongly indicates that to obtain the best yields of any crop the variety used should be adapted to the existing conditions. Adjoining farms frequently differ markedly from each other in soil conditions and a variety best suited to one may not be satisfactory on the other. Variety-testing is thus an important part of the farm work and should be followed by a careful selection of the seed in order to secure a high yielding strain of the variety which will be suited to the local conditions.

For many years farmers have given careful attention to the methods of seeding, cultivation, manuring, and the like, but have generally neglected to give any careful attention to the methods of seed selection or breeding. They have universally recognized the importance of stock-breeding and on all dairy and stock farms more or less careful attention has been given to the matter of breeding and improvement of the strain grown. To every farmer the field of breeding, whether in plants or animals, furnishes an interesting and profitable diversion. Plant-breeding especially should become a farmer's fad. Few can afford to breed animals in the extensive way necessary to secure important results, owing to the expense. No farmer, however, is so poor but that he can have his breeding patch of corn, wheat or potatoes. Indeed, if they but knew it, they can ill afford not to have such a breeding patch to furnish seed for their own planting.

Much regret has been expressed because our boys and girls become dissatisfied with farm life and remove to the cities. This, the writer believes, is largely due to lack of interest and apparent opportunity on the farm. Get the boy interested in improving the field crops and the girl interested in improving the garden vegetables, the orchard fruits and the flowers, and the writer believes that much of this dissatisfaction would be overcome. Have the boy develop an improved race of corn, wheat, potatoes or some useful crop, keeping records of yields in comparison with ordinary sorts. Let him exhibit the product at the county and state fairs, and sell the seed of the improved strain to his neighbors. It will prove a profitable investment of time and money and give zest to the farm work. Riley, the Indiana farmer who bred the Boone County White Corn, was an ordinary farmer, not a scientific experimenter. Yet his variety is grown extensively over a dozen of the great corn states and has added thousands upon thousands of dollars to the valuation of the corn crop of the world. Many of the standard varieties of our ordinary crops have been bred by our farmers, and the time has come when such services to humanity will be recognized and recorded in history as are the noteworthy deeds of other great men in other fields of human industry. At the present time probably no field of human activity offers greater opportunity for advancement and reward than the field of agriculture and when pursued with intelligence and energy, success is almost certain.

I. Some of the Factors in Plant-Breeding.

If one is to use the most comprehensive methods of breeding, the operations become very complex and few farmers would have the time to undertake the work on so extensive a scale. The writer has in most cases described comparatively simple methods and in some cases has outlined more complex methods. No matter what breeding or seed-selection the farmer is pursuing he should be familiar with the general principles involved and an outline of the most fundamental principles, is thus given.

The simple methods of seed-selection outlined under certain crops treated, could hardly be considered breeding, but the methods are given as they will lead to considerable improvement and are important to follow where the farmer is not in position to follow more careful methods.

In the present bulletin no attention is given to the use of hybridization in the origination of varieties, as this field of breeding is too complex to be pursued successfully by farmers generally. In some future bulletin the writer hopes to discuss this subject for the benefit of those who may be interested in following breeding in a more specialized way.

What is meant by pedigree-breeding.

In animal-breeding, it is generally understood that pedigree-breeding means the breeding from registered parents and it is generally recognized that wherever breeding of this kind is carried on it is done very carefully. Pedigree-breeding has come to be almost synonymous with the use of care in selection. The breeder who goes to the trouble and expense of registering an animal, is certain to give very careful attention to the characters of the animal, and to know that it is above the average, before having it registered. No means has yet been devised of registering plants in the sense in which such a practice is carried out in animals and we, therefore, have no general breeding of plants under this system, except in an experimental way. Ordinarily speaking very little care is used in the selection of corn, wheat, potatoes, or other seed. Indeed, it may be said that it is an exception to find farmers giving careful attention to the methods of seed-preservation or selection. The most common practice with corn, certainly until recent years and still very generally used, was simply to select the best ears from the crib each spring to use as planting seed, growers thinking they could judge of the germinability of the corn by the appearance of the ears. With wheat and oats, no selection is practiced generally other than possible to screen the seed before planting, in order to separate the largest and heaviest kernels from the smallest and lightest.

The practice of pedigree-breeding stimulates care in selection, advertises the grower's stock, and has proven so successful in animal-breeding that it has been adopted by breeders of all of the important types of domesticated animals. The experiments of plant-breeders have been carried far enough to demonstrate beyond doubt that any strain or variety can be improved in yield and other qualities by careful selection and pedigree-breeding. It would seem to the writer, therefore, that the time has come when New York growers should adopt standard methods of breeding for plants and provide some means of registration of pedigree strains and new varieties and races. This would stimulate the grower to careful work and furnish him the protection and stamp of authority which is given by an official pedigree or certificate.

Difference between plant-breeding and animal-breeding.

For many years farmers have given special attention to animal-breeding and are familiar with the methods there employed. It is thus desirable that they clearly recognize such difference as are of importance between animal and plant-breeding. In animal-breeding the production of new races or breeds is very rare. The ordinary breeding has as its object, improvements with the race or breed, such as, increased size,

greater milk production, improved beef quality, increased fecundity, or some such quality not changing the characters of the breed as a whole.

The plant-breeder ordinarily strives to produce new races or breeds, differing from the known sorts in some important characters by which the variety or race may be recognized. The new varieties or races of the plant-breeder would correspond to the different breeds of animals.

The striving after markedly new varieties has led the plant-breeder to largely overlook the advancement that may be wrought within the variety by pedigree-breeding.

The plant-breeder can handle thousands where the animal-breeder handles tens.

In careful pedigree-breeding, the animal-breeder follows both male and female parents carefully selecting both. In the ordinary pedigree-breeding in plants only the female parent is known and recorded, although through planting the breeding stock in isolated fields, the male is known to have come from a good mother parent. In some special cases male and female are both followed in plants by practicing hand-pollination.

In general, therefore, in plants the female is most generally followed, while in animals the male is, if anything, considered most important, In animals many herds are greatly improved by simply introducing a good male; in plants many crops are greatly improved by simply selecting good females as seed producers.

What are variations?

The fact that we are able to improve plants by selection depends upon the occurrence of variations. We are accustomed to think of plants as a whole as very stable and uniform. As we casually look over a field of Ox-eye daisies and admire their beauty, we distinguish no apparent variability; all seem to be alike. Nevertheless, if we examine the plants carefully and study the different individuals we find that each one possesses certain peculiarities. Some have large flower heads, others small flower heads; some have very many rays or petals, others comparatively few; some have broad rays, others narrow rays. Some plants are tall, others short. Some plants are many flowered, others few flowered, and the like. No two plants can be found which do not differ from each other in some noticeable character. They present different facial expressions, the same as do people or cattle, so that we may recognize different individuals apart after we have studied them and made their acquaintance. We are not accustomed to being introduced to Sam Ox-eye, Jim Ox-eye and John Ox-eye and attempting to recognize their characteristics so we will know them when next they call. This, however, is one of the interesting studies which the breeder pursues. Care-

ful gardeners learn to recognize the individual plants which they handle day after day the same as the shepherd recognizes the different members of his flock. These ordinarily slight variations which are spoken of commonly as individual variations are what the scientists now call continuous or fluctuating variations.

All of the individuals of any species, rase or variety, whether wild or cultivated, show these individual variations. If we examine the different seedling trees in nursery rows of maple or oak, or different corn or wheat plants in fields of the same race, we will find them to present similar individual variations. These variations are congenital, that is are born with the individual, and are apparently not caused as a direct result of of the environment. In many cases such variations are transmitted by a plant to its progeny in the same manner that many of the individual characters or characteristics of a human being are in part at least transmitted to his progeny.

Such slight individual variations are the type of variation most used by animal-breeders in selecting to improve the breed. In plant-breeding such individual variations are also used when the breeder is selecting to produce an improved strain of any race. If, for example, the breeder desires to produce a heavy yielding strain of the Pride-of-the-North corn, he would select individuals having the maximum yield, plant these in isolated places and continue the selection year after year, until a high yielding strain of the variety had been produced. In such a selection the scientist would assume that there had been no change produced in the type of the race but that the breeder by the selection and isolation of the maximum yielding individuals had produced a family, within the race, of high yielding capacity, this being maintained continually by the selection. If, however, the selection and isolation of the highest yielding plants was discontinued and free intercrossing with inferior individuals was allowed, the mean yielding capacity of the race as a whole would soon be established again.

A second type of variation is that known to gardeners and horticulturists as sports and to the scientists as mutations. These are large pattern, striking variations which do not occur very commonly, but which, when found, are likely to prove useful in the production of new types of value. The recent scientific studies of De Vries, a famous botanist of Holland, have emphasized the great importance of such variations in the production of cultivated varieties and the evolution of species. As is well known to gardeners these sports or mutations, appear suddenly without warning or reason so far as we know. We cannot produce them and must simply wait until they appear and then be prepared to recognize and propagate them. Mutations usually reproduce their characters without much reversion to the parental type except such as i-

caused by cross-pollination. Mutations of self-fertilized plants thus usually come true to type, while in cross-fertilized plants the mutation must usually be cultivated in an isolated place and carefully selected to weed out the effect of such crossing as has occurred. Many seedsmen examine their trial grounds regularly for the sports or mutations and many of our best varieties have resulted from the selection of such sports. Livingston, of Ohio, who during his life was famous for the number of new varieties of tomatoes which he produced, made it a practice to regularly search the fields of tomatoes which he grew for seed purposes, for such sports and almost all of his numerous varieties were produced by the discovery of such striking variations.

From what has been said above it will be seen that fluctuating variations are of value mainly in the production of improved strains of a race which differ only in such characters as high yielding capacity, which are soon lost when the selection is discontinued. Mutations or sports on the contrary are of value in the production of distinctly new races and varieties which maintain their new characters without continued selection.

Aside from the above types of variations we have another type usually known as physiological variation which is the direct reaction of the plant to a certain environment. A simple illustration of such a variation is the difference in size due to growth on sterile and rich soil. Such variations are not ordinarily inherited and are not known to be of any value to the plant-breeder.

Another kind of variation, probably of little value to the breeder of annual plants and about which we as yet know very little, is the so-called bud variations, sports or bud mutations. Chrysanthemum and rose growers know that it is not a very uncommon thing for a plant to produce a branch which will be entirely different from the remaining portion of the plant. Valuable new varieties of roses, chrysanthemums, carnations and some other flowers and fruits have been secured by the selection and propagation of such bud variations. They seem in a large measure to be comparable to mutations except that they originate in a bud change instead of a change occurring in the sexual reproduction. It is probable that they will ultimately be found to be due to similar causes, being produced in the same way.

The forcing of variations.

Little is known as yet as to how far we can go in forcing the variations of various types, other than through the hybridization of different strains, varieties and species. The evidence now at command, indicates that plants become more variable as they are highly fed and are manipulated in various artificial ways, such as, budding, grafting and vegeta-

tive propagation in general. A change of environment may cause apparently stable races to break up and vary considerably, especially when such races are of hybrid origin or are highly bred sorts. A radical change of environment may, therefore, in some cases lead a plant to break up and produce certain variations that we desire.

The recent investigations of Dr. MacDougal indicate that we may be able to induce or stimulate a plant to produce mutations or sports through the injection into it at certain periods, of chemical salts. This, however, is at present a field of experimentation for the scientist rather than for the practical breeder.

One of the most fruitful ways of causing variation is by hybridization, but owing to the complexity of breeding work of this kind it will not be discussed in this paper.

Principles of selection.

The keynote of improvement by selection is the choice of the very best individuals. The discovery of the best individual in any crop under consideration, requires the growing of a large number of individuals under as uniform conditions as possible, so that the experimenter may have opportunity to examine and select the best. Two methods of growing plants for selection are in general use which may be termed 1, the Nursery method and 2, the Field method.

The Nursery method, which so far as the writer is informed was first used by Hallett about 1868, consists in cultivating each plant under the most favorable conditions possible for its best development. By this method with wheat, for instance, Hallett pursued the policy of planting the individuals in squares a foot apart, which would give each plant abundant opportunity for stooling, and also the investigator an opportunity to clearly distinguish each individual plant and determine its characteristics, total yield, and the like. In recent years this method of growing the individual plants at a standard distance from each other in order to test their yielding capacities, and the like, has been used by Professor Hays in his experiments at the Minnesota Station. Here, however, a standard distance of four inches apart was used instead of one foot.

The Field method was used by Rimpau about 1867, and probably by many others before that time. By this method, the selections are made from plants grown under normal field conditions. The claims for this method is that we can only judge what a plant will do in the field under ordinary conditions of field culture, by growing and selecting it under these conditions. In the large majority of cases the first selections are probably made from plants grown in the field in the regular course of crop production, which thus were not specially grown for the purpose.

If one is to use the Nursery method, the plants must be especially planted. While the nursery method certainly allows the breeder to distinguish the individual plants more clearly, in crops like wheat, oats, and so on, which are sown broadcast or drilled, it entails very much extra work and is probably to be recommended only for the use of experimenters who are giving their entire time to the work.

In selecting the best plants in any crop the breeder must aim to examine a very large number of plants and carefully compare their important characters. To know what the important characters are, it is necessary to be familiar with the crop and have a thorough knowledge of those qualities which go to make up a plant of the greatest intrinsic value. In some cases breeders have given primary attention to some quality which is largely secondary in nature. Corn-breeders, as an illustration, have given great attention to getting ears well filled out over the tip. This character is of no value except to produce a good ear for exhibit and would be of no value there if the ordinary score card did not require it. Such a character is of no value, unless it is correlated with heavy yield, and the writer knows of no evidence to show that this is the case. What the corn-breeder desires is the variety that will give the largest yield per acre of good grain. If this variety happens to bear ears well filled over the tip, well and good. The filling of the tip is not a detrimental character. If, however, this heavy yielding capacity is found in a variety in which the tip of the ear is not so well filled it does not materially matter, as this in general is not a detrimental character.

In making the first selections it is usually the best policy to make a preliminary selection of a much larger number of plants than are actually desired. The breeder can then examine these selections with greater care and discard the poorest from among them retaining only the superior individuals.

Careful breeders have found it very desirable to have a clearly defined ideal type which they are striving to produce. In selections within the race the breeder should have all of the characters of the race which he is breeding clearly in mind in order to adhere strictly to the type of the variety in the selections. In making selections of new variations, mutations, etc., in attempting to secure new races, naturally no one type can be adhered to. In testing these different individuals, however, the characters of a certain type should be borne in mind and deviations from this type in the progeny should be weeded out.

The individual the unit of breeding.

The unity of the individuals is also an important factor in plant-breeding. If, for instance, one is attempting to produce a seedless fruit, it is important that he discover a plant which shows a tendency to produce

seedlessness throughout the entire individual. It would not be the correct policy for a breeder to select simply a single fruit which might accidentally be nearly seedless. He should examine a large number of fruits of different individual plants, and find a plant on which he can discover a general tendency toward seedlessness, showing in all of the fruits produced. By selecting seed from such individuals he may be able to find in time one such individual that would transmit to its progeny this tendency to produce few seeds.

While this is certainly generally true, there are some instances in which further divisions of the individual are important. As an illustration may be mentioned the case of color in corn kernels. Where one is dealing with hybrids of corn of different color it is well known that the kernels on the same ear may vary in color, and if the investigator is attempting to produce a certain color he should select to plant only those kernels that have the color which it is desired to produce in the new strain.

In head selection of wheat and oats made in the field as described in another part of this bulletin, one is in a sense basing the selection of an individual on the examination of one part. However, this head selection should be accompanied by an examination of the plant to some extent and even if this is not done the planting of each head in a test row by itself to determine comparative yield, gives a measure of the productivity of the original plant from which the head was taken and this after all is the important point.

Again in clonal-breeding[1], the unit used is any part or portion of the plant that shows a desired variation. In potatoes where the hill method of selection is used the unit would be the tuber producing the hill, and the yield of the hill would be the measure of the productivity of the bud that produced the tuber. In breeding carnations, violets, pineapples, and the like, by the selection of cuttings or slips, the plant grown from the slip or cutting becomes the unit representing the productivity of the bud which produced the slip.

Test of transmitting power.

A factor of primary importance in all pedigree or grade-breeding is the testing of what is termed the transmitting or centgener power. It is necessary for us to know that a certain plant, which for instance, gives a heavy yield, has the faculty of transmitting this tendency of producing heavy yield to its progeny. It is frequently found that two select plants which are equally good so far as their yield is concerned will give progeny which, as a whole, differ greatly in this respect. In the progeny of one almost every plant may have inherited the quality, while in the

[1] Clonal-breeding,—breeding by the selection of vegetative parts, buds, scions, tubers, bulbs, slips, etc.

progeny of the other only a few of the plants may show in any noticeable degree the inheritance of the quality. To determine this prepotency or transmitting power, it is necessary to carefully grade the progeny of each individual, and this is the primary reason for planting the progeny of different individuals in separate rows or separate plots, so that they may be easily examined. It would seem to be an easy matter when we plant the progeny of different plants in rows or small plots by themselves to get the comparative yield, for instance, of 100 plants, and from this figure up the average per cent of the transmitting, or centgener power. This matter, however, is very difficult in many cases. In corn, for instance, certain individuals may stool and form suckers that have fairly good sized ears. If the corn is planted thin enough on the ground, these suckers would tend to increase the yield, and render the proper judgment of the transmitting power very difficult. It would seem at first thought that such suckering, if it increased the yield would be desirable, and should be considered a favorable character in connection with an individual. However, if the soil is heavy enough to have allowed this suckering to give increased yield, it would have been possible on the same soil to have placed the plants closer, and as seed is of little comparative value, it would be best to have a non-suckering type, and plant the corn as closely as the soil would properly permit. Again, it is almost impossible to get perfect stands, and a change in the stand may affect the yield. Very many difficulties and problems enter into the figuring out of this transmitting power, and it is obviously impossible to give directions for all cases. The breeder must study conditions and carefully determine what policy to pursue in each case.

Control of parentage.

In plant-breeding, as in animal breeding, the isolation of the parents is a very important consideration. It is necessary that we should know the character of both parents wherever this is possible. In breeding plants more attention is ordinarily given to the mother plant, and in very many instances the characters of the father plant are entirely neglected. Animal-breeders, on the contrary, give more attention to the characters of the male parent, and a great deal of improvement in ordinary herds is accomplished by the introduction of improved blood through the male. In plant-breeding it is desirable that the seed of the select individuals be planted in a field by themselves. This insures that only progeny of carefully selected plants will be planted near together, and thus no ordinary stock will enter in as a contamination. One can be certain that each plant of the progeny is fertilized with pollen from another similarly good plant, or at least from a plant derived from good parentage. One difficulty, however, has been experienced by plant-

breeders in the case of plants which normally cross-fertilize, in planting continuously their selected stock in such isolated plots. If this method is continued year after year, it results in fairly close inbreeding, which in the case of plants frequently results in loss of vitality and vigor. In animal-breeding it is apparently the case that ordinarily with careful selection, there is no noticeable effect from close inbreeding, and many of the most famous animals have been produced as a result of the closest in-and-inbreeding. In plants, however, it is possible to secure much closer inbreeding than in the case of animals, as in many cases a plant can be fertilized with its own pollen.

Within recent years much activity has been developed in the careful breeding and improvement of corn. The corn plant has been shown, as a result of experiments carried on by various investigators, as, for instance, the Illinois Experiment Station and by the U. S. Department of Agriculture, to lose vitality very rapidly when self-fertilized. Within three or four generations by careful self-fertilization it is possible to produce a strain of corn of almost total sterility. The general practice of corn-breeders who have been giving attention to the production of highly bred strains is to plant the rows of corn from different select ears side by side, giving a row to each select ear, and each year selecting from the progeny of those rows which give the largest yield, further plants to continue the selection. Planting these select ears together every year, therefore, means that they are more or less inbred as the closest relatives are planted together in the same row. While in following this policy at first no effect was visible, corn-breeders are now finding in some cases an apparent decrease in yield, which seems to be traceable to the effect of inbreeding. It, therefore, seems necessary for us here and in other plants that are effected by inbreeding to devise some methods that will avoid close inbreeding. Methods for the use of corn-breeders will be described later in this bulletin. The detrimental effect of inbreeding is largely limited to those plants which are normally cross, fertilized, this fact being strikingly brought out in Darwin's famous "Investigations on Cross- and Self-fertilization in the Vegetable Kingdom." Tobacco, wheat, and some other plants which are normally self-fertilized do not show this decrease in vigor as a result of inbreeding. Indeed, in such plants, cross-fertilization ordinarily results in decreased vigor and should be avoided.

Obviously in the case of clonal-breeding, such as the improvement of potatoes by hill selection, the isolation of the breeding stock does not have to be considered and the breeding and increase patches can be planted with the general crops if so desired.

Numbering the selections and keeping records.

In practical work, it is necessary to limit note-taking and records to the minimum as it is easy to spend so much time in making records, that no time remains for the more necessary work. It is, however, necessary to follow the individuals in each generation sufficiently so that one can trace back the parentage and compare the results of different years in order to determine which strain or family has proven the best. A simple way to do this is the following:

Suppose we are making selections of Leaming corn and that the breeder has carefully examined a good field of Leaming and selected fifty superior plants. When these plants are harvested they can be numbered in sequence 1, 2, 3, etc., up to fifty. The seed of each plant should be preserved separately and the number assigned to each plant placed on the packet containing the seed. In a special record book obtained for this purpose, records can be made on the individuals selected under the numbers assigned to them, and under the general heading of *1907 Selections*, or any particular year in which the selections are made. The next year in practically all breeding the seed from each plant requires to be planted separately by the plant-to-row method, to test the transmitting power of the individual. These rows from the various individuals should be labeled in accordance with the numbers assigned to the selections, 1, 2, 3, etc., to 50. When the selections of the second generation are made from these rows, label those from row 1 as follows: 1–1, 1–2, 1–3, etc., those from row 2, label, 2–1, 2–2, 2–3, etc., those from row 50, label, 50–1, 50–2, etc. Make notes on the selections under these numbers and under the heading of *1908 Selections*. It is important also to carefully examine each row and determine how the characters for which the plant was selected have been transmitted. Ordinarily, the record of yield of the progeny is the most important factor to record.

In the third year, the selections made from row 1–1 of the second year selections would be labeled 1–1–1, 1–1–2, 1–1–3, etc.; those from row 2–1 would be labeled, 2–1–1, 2–1–2, 2–1–3, etc. In later generations, the same system can be followed, separating the different years by a dash. It will be seen that after the first year the system consists of numbering the selections made from any row 1, 2, 3, and upward, and placing before it the number of the row with a dash separating them. By examining this system it will be seen that these numbers show at a glance the number of the generations through which the selection was continued, and also connects each generation with the preceding generations, so that the record of any selection can be traced back through the entire time the selection has been continued.

Should the selection be continued longer than about six years these numbers will become cumbersome and in this case new numbers can be given to all selections made in any year, numbering them again 1, 2, 3, and upward. Under each of these a record can be made of the row from which it was taken, which will connect it with the preceding records; thus, No. 1 (from row 2–1–3–5–2–4) etc.

With reference to keeping the notes the following is a suggestion of arrangement through three years:

1907 Selections.

Leaming corn
- No. 1 (followed by notes on individual)
- No. 2 (" " " " ")
- No. 3 (" " " " ")
- etc.

1908 Selections.

Leaming corn
- 1 (Followed by progeny notes)
  - No. 1–1 (Followed by notes on individual)
  - No. 1–2 (Followed by notes on individual)
  - No. 1–3 (Followed by notes on individual)
  - etc.

- Row 2 (Followed by progeny notes)
  - No. 2–1 (Followed by notes on individual)
  - No. 2–2 (Followed by notes on individual)
  - No. 2–3 (Followed by notes on individual)
  - etc.

1909 Selections.

Leaming corn
- Row 1–1 (Followed by progeny notes)
  - No. 1–1–1 (Followed by notes on individual)
  - No. 1–1–2 (Followed by notes on individual)
  - No. 1–1–3 (Followed by notes on individual)
  - etc.

- Row 1–2 (Followed by progeny notes)
  - No. 1–2–1 (Followed by notes on individual)
  - No. 1–2–2 (Followed by notes on individual)
  - No. 1–2–3 (Followed by notes on individual)
  - etc.

Row 1–3 (Followed by progeny notes)
No. 1–3–1 (Followed by notes on individual)
No. 1–3–2 (Followed by notes on individual)
No. 1–3–3 (Followed by notes on individual)
etc.

Row 2–1 (Followed by progeny notes)
No. 2–1–1 (Followed by notes on individual)
No. 2–1–2 (Followed by notes on individual)
No. 2–1–3 (Followed by notes on individual)
etc.

II. CORN.

While corn is extensively grown in New York and is one of our most important agricultural crops, as a whole it seems to the writer that it is a much neglected crop. It is grown largely for ensilage purposes, but only to a limited extent for the grain. New York produces an abundance of hay and roughage but has a shortage of concentrates. If more attention was given to the improvement of corn it is probable that its cultivation for grain would become more general. We greatly need earlier dent varieties of higher yielding capacity. In the majority of cases where corn is grown for the grain, flint varieties are yet used, although dent varieties are in general higher yielders. When corn is grown for ensilage the seed is quite generally obtained from Ohio, Illinois, or some of the western corn states, when it is probable that by careful breeding we could produce local strains that would give just as good or better yields and which would have the additional advantage that the seed could be produced here with safety. The writer is well aware that many corn growers would claim this to be improbable or at least, impractical, as they believe that the growth of the seed in a more southern location gives the plants a tendency to grow large and rank, a character which they believe would be lost if the variety were grown continuously in the north. The writer, while admitting that the general tendency for a variety grown in northern localities where the season is of limited duration, is to become smaller, nevertheless, believes that by the proper breeding, varieties could be produced which would ripen seed safety and because of their better adaptibility give even better results for ensilage purposes. Corn which matures sufficiently for good ensilage has reached a stage when the ears, if properly preserved, will give seed that will grow well. A reduction of a week in the season of such a variety would probably render it sufficiently early so that mature seed could be selected.

Corn is a crop particularly well adapted to breeding as the selection of sufficient seed to plant a comparatively large area does not entail very much work. The breeding, however is complicated by the fact

that corn is normally cross-fertilized and the breeding plot thus requires to be isolated to prevent the injury of the select strain by crossing with inferior plants.

Corn-breeding has received very much attention from breeders in recent years and several very complex methods have been devised for conducting systematic work in improvement by selection. These methods are rendered complex by the necessity of arranging the selected individuals in such a way as to avoid self-fertilization and too close inbreeding, and the consequent loss of vigor. The three methods most generally used are those suggested by Dr. C. G. Hopkins and his associates of the Illinois Station, by Professor C. G. Williams of the Ohio Station, and by C. P. Hartley of the U. S. Department of Agriculture. These methods are all rather complex for use in general, but when once understood and in actual operation, their complexity disappears in a measure. This, at least, is the testimony of farmers who have been actuallly engaged in the work and put the methods into operation, and the writer can see no reason why many farmers should not adopt some one of these methods for their use. The method devised by Mr. Hartley is probably the simplest method that takes into account the prevention of too close inbreeding and is thus believed by the writer to be the best method thus far devised for the general use of farmers. This is, therefore, the only method described in this bulletin. If the farmer becomes a special corn-breeder and wishes to conduct his work in the most scientific way he should study the methods used by Professor Williams and Dr. Hopkins.

FIG. 135.—*Well-shaped cylindrical ears of corn.*

Some important characters of corn.

Probably the most important character to be considered in connection with corn-breeding in New York is the production of earlier strains of good yielding capacity. This is particularly true in the case of dent varieties, the growth of which should be encouraged.

The best corn variety for any section is that sort which ripens sufficiently early to mature its crops before freezes are liable to occur, and gives the best yield of good grain. A variety, however, should be late enough to utilize the entire growing season available in the locality. Every variety of corn which the writer has examined shows considerable variability in the season of the different individuals and it is clearly possible to shorten or lengthen the season of any given variety. The stalk should be vigorous. productive and leafy. If early enough for New York conditions it is not likely to be too high as sometimes occurs farther south. Ordinarily a stalk which does not produce suckers is considered the most desirable. It is also important that healthy stalks free from smut or rust, either on leaves, ears, or tassels should be selected. A good ear of corn in general should be cylindrical in shape and of about the same diameter from base to tip (Fig. 135). It is very easy to find ears too long and slender to give the best results. The ear giving the largest weight of shelled corn of good quality and grade is in general the best ear. The ears which give this ordinarily have deep kernels set on a medium sized cob and are generally well filled at the tip and butt (Figs. 136 and 137). Length of kernel is one of the most important characters, as almost always, if not invariably, high yielding varieties have long kernels. The best form of kernel is wedge-shaped with straight sides and edges. This allows them to occupy all the space on the cob and form a solid heavy ear (Figs. 138 and 139). They should not be chaffy nor have prolonged chaffy caps.

FIG. 136.—*Kernels short and undesirable on left-hand ear; kernels long and well-shaped on right-hand ear. Pride of North corn.*

It has been shown by the experiments of Dr. Hopkins and his associates in the Illinois Experiment Station that it is possible to increase the nitrogen, oil, or starch content of corn by careful selec-

tion but it is not the intention of the writer to urge this as a desirable line of breeding work for the ordinary farmer to undertake at the present time. In general, however, a breeder should understand that those ears on which the kernels by cutting show a considerable portion of hard, horny or hyaline matter, are rich in nitrogen. The kernels on some ears have a large quantity of rather soft, opaque, white matter and those are rich in starch but poor in nitrogen. As ears with higher nitrogen content are what we desire, ears with a large proportion of white starchy matter should not be used in propagation.

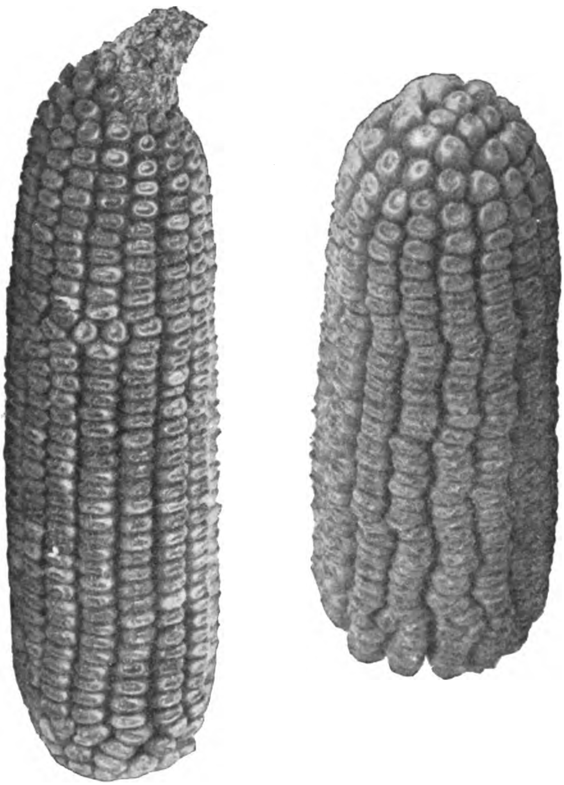


FIG. 137.—*Poor tip and good tip, Pride of North corn.*

With reference to the number of ears per stalk which will give the best results, no very definite statements can be made. One good ear per stalk would give us high yields, however, and the writer is strongly inclined to the opinion that with dent varieties in this rather northern region a single ear to the stalk will prove in general the most satisfactory.

If the breeder selects large ears, in general he will be breeding toward a one ear per stalk type as the ears on one eared stalks will naturally be the largest. The writer believes that growers in general know a good stalk and a good ear of corn but in determining the yield of shelled corn per ear it will be better ordinarily to weigh the product as it is well in all cases to use exact methods where possible rather than trust to judgment.

Choosing the variety with which to begin.

The choice of the variety or kind of corn with which to begin the breeding work is an important part of the process. What has

been said above applies to dent varieties which in general are the highest yielders, but which require a rather longer season in which to mature.

There are several varieties and strains of dent corn which are grown locally in different parts of New York for seed and satisfactory dent varieties for all of the corn-growing sections of the State can doubtless be produced. The breeder should above all start with a strain which he knows to be a high yielding type. If he knows of no such type which is fairly well suited to his section he should probably obtain seed of several varieties which appear promising, and test their yield on his farm. He may find it desirable to consult the Experiment Station regarding varieties and such information as possible will be freely given. It may be stated that in general, Pride-of-the-North or some selected strain of this variety, such as Minnesota No. 13, appears to be one of the most promising dent

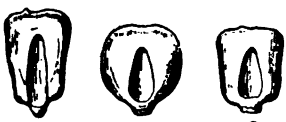


FIG. 138.—*A, Kernel of proper shape. B, Round kernel. C, Square kernel, From "Examining and Grading Grains."*

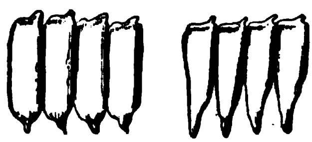


FIG. 139.—*A, Kernels fitting closely from crown to tip. B, Kernels pointed on narrow side. From "Examing and Grading Grains."*

varieties for the State (Fig. 140). The writer's experience, however, is not yet sufficiently extensive so that he can recommend this variety to the exclusion of others and it is very probable that no single variety can ever be found which will prove to be superior in all sections of the State. If the grower is cultivating a strain which has given him satisfactory results it would be a good sort to breed regardless of whether or not it is a known variety.

The sort which the grower is going to use in his breeding having been decided upon a field should be planted with the best available seed. If a large quantity of this corn is available the best possible ears should be selected for planting seed and these planted by the ear-to-row method used in planting the breeding plot as described below. A field of several acres should be planted in order to furnish sufficient plants so that a good selection can be made. This should be placed in a field where the soil is as uniform as is possible to obtain.

Making the first selection of corn.

When the corn begins to ripen the work of selection should begin. In this State where earliness is so important the selections should be made when the earliest stalks ripen and begin to dry. At this time the grower can judge the degree of earliness quite accurately, and can limit his

selections to the earliest plants. The field should be gone over slowly and carefully, row by row, and the best productive early plants marked for seed. The grower should select an ideal type so far as the variety he is selecting is concerned and adhere as near as possible to this type. The aim should be to select a hundred or more of the best ears from the earliest and most desirable stalks. Always select about twice as many ears as desired so that some of them may be discarded when examined in detail later. When the plants have been selected the ears should be husked and taken into a dry room for preservation or the stalks should be cut and placed in a dry room where they will dry quickly and without injury from freezing. If the ears are pretty thoroughly ripened the best policy is doubtless to husk them immediately and if rather immature

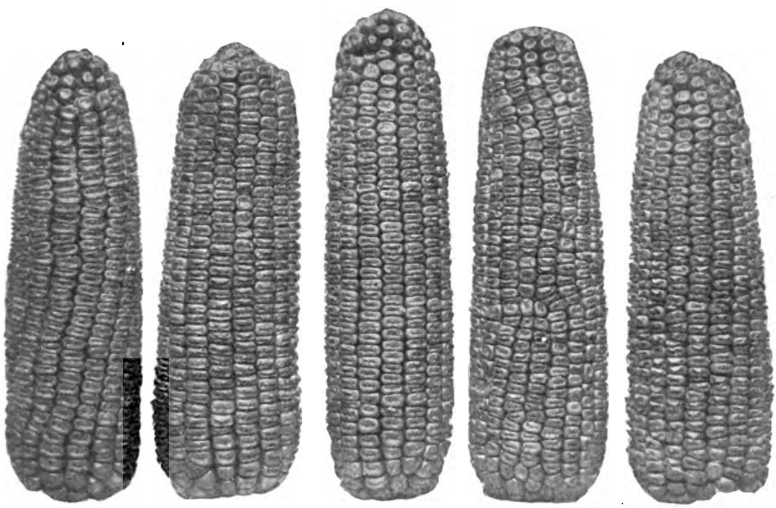


FIG. 140.—*Typical ears, Pride of North corn. Crop of 1907, New York.*

when selected and there is danger of freezes it may be well to cut the stalks and allow them to dry and ripen on the stalks by placing these in a sheltered, warm place. In general seed corn should be dried quickly and thoroughly and to do this the ears should be hung over wires in a warm room or placed loosely on open shelves where the air can circulate freely around them. If a stove can be placed in the seed room it is desirable to use some artificial heat.

In the winter when there is no rush of farm work to interrupt, place the seed ears selected in rows on a table with the tips of the ears pointing in the same direction. Then examine every ear critically as to type, shape, depth of kernel, and other desirable characters. A few kernels taken out from near the tip, butt and middle of any ear will show the general character of that ear. If the kernels of any ear are too short or

defective in any other character the ear should be discarded. Select out 50 or 100 of the best ears and preserve these to plant a breeding patch the next year. These should be shelled by hand. First shell off the poorly formed tip and basal kernels which should be discarded. Then shell the remaining portion of each ear and place the seed of each in a separate paper bag. Number each ear in accordance with the system described in early part of this paper (page 142) and carefully label the seed and record under this number the length, diameter and weight of ear, weight of shelled corn and any other notes which you may desire to retain. Typical ears of each generation should also be retained for comparison. The discarded ears should be shelled and retained as planting seed for the general crop.

Planting the corn breeding-plot in second year.

The breeding-plot should be located on a uniform piece of land of good quality but representative of the land of the region. It should not be especially manured or cultivated but given ordinary good care and ordinary manuring. The seed from the various selected ears should be planted by the ear-to-row method, the seed from one ear being placed in one row, etc. The rows should be planted at right angles to the dead furrows and back furrows, and if on a side hill the rows should be planted so that each has the same proportion of high and low land so far as possible. The rows in this year may be planted in order of number. It must be remembered that corn is regularly cross-fertilized and the breeding patch must be located at some distance from any other corn field preferably at least a thousand feet distant. It might be planted in the corner of a field of the same variety if no other place is available, but this is undesirable for then many ears of the breeding patch will be pollinated with pollen from unselected individuals. If such a location must be used the ears that were discarded after the last careful examination should be planted around the edges of the breeding patch between it and the other corn. It is far better to have an isolated plot for the breeding-field, however, and this should be arranged if possible.

It is desirable to have all rows of the breeding-plot of equal length and containing the same number of hills and same number of stalks per hill. It is a common practice to plant about 100 hills from each ear. It is also desirable to have one or two border rows all around the plot to make the conditions of all hills uniform. These border rows can be planted with the seed left over after planting the selection rows.

The planting can be done by hand or with a hand-planter. In the latter case the planter must be carefully cleaned after planting each row. It is also well to drop the corn thicker than desired so that it can be thinned to a uniform stand when well up and about six inches high.

Detasseling to prevent self-pollination.

It has been proven by careful experimentation that corn is reduced markedly in vigor and production as a result of inbreeding and self-fertilization. Planting by the ear-to-row method gives opportunity for considerable inbreeding and self-fertilization and to avoid this it is necessary to detassel certain portions of the breeding-patch from which seed is to be taken. The simplest method of accomplishing this is to detassel one half of each row. In order that this may not interfere with proper pollination each row is detasseled from one end to the middle alternating ends of adjoining rows being detasseled as illustrated below, the dotted line indicating the portion of each row detasseled.

Row 1 ....——————————————
Row 2 ——————————————............................
Row 3 ....——————————————
Row 4 ——————————————............................

It will be seen from an examination of this method that the seed formed on the detasseled portions of each row will all of it have been cross-fertilized with individuals from another select row which in this first generation is probably quite distantly related.

The process of detasseling is accomplished by pulling out the tassels before they begin to discharge pollen which will entirely prevent self-fertilization. In order to do this work thoroughly the field must be gone over every two or three days at the time of tasseling. An examination of all the rows should be made at this time and if any rows are found to show weakness or undesirable characters they should be detasseled throughout so that they will not affect the remaining rows by crossing with them.

Making selections from the breeding-plot of corn.

After detasseling nothing remains to be done until the stalks begin to ripen and the ears to dry. At this time the number of stalks in each row should be counted and recorded. If border rows have been planted these of course should be excluded from the count. It now remains to select the best plants from this patch. The field should be gone over with the ideal type well in mind and the best plants marked. All of these should be taken from the detasseled portions of the different rows. As in making the selections the first year about twice or three times as many ears should be taken as are finally desired. These should be taken from the most productive rows so far as can be determined at this time. It is necessary to take seed from all of the apparently good rows as it is impossible to tell which are the best rows until the product from the different rows is measured and weighed. The select ears from each row should be kept together under the row number and spread out to dry in a warm, well ventilated room.

Determination of the most productive rows.

As soon as the corn is ripe enough to harvest, the different rows should be harvested separately and the product carefully weighed. The ears which have been previously selected from each row should also be weighed and the total product of each row determined. Having now the total product of each row and the number of stalks per row, the average yield per stalk can be determined by dividing the yield per row by the number of stalks that grew in the row. In rows which have nearly a perfect stand this gives a fairly reliable estimate of the comparative yield. If the stand of certain rows is much broken they will have to be thrown out of the calculation. If all of the rows are much broken in stand, no reliable data can be obtained as to the comparative yield and the breeder will have to depend on his judgment.

The average row production is a test of the transmitting power of the ears selected in the first generation and the heavy yielding rows are thus the ones from which the selections for the further breeding should be taken. At some convenient time the selections made from the breeding-plot should be laid out on tables and carefully examined. Those which are taken from rows which were found to be low yielders should be discarded.

All of the selections finally retained should be from the ten or twelve highest yielding rows. Examine all of the ears in detail and finally retain about the same number as were selected the first year. These should then be numbered with the row number and individual selection number in accordance with the system previously outlined (p. 142) and notes recorded similar to those made on the first generation ears. The progeny or row yields should also be recorded. The ears after shelling off the poor kernels at apex and butt can be shelled and preserved in separate sacks ready for planting the breeding-plot the next year.

It is a good policy after selecting all of the ears for planting to retain a number of the second select ears as a safeguard against any accidental loss of those planted and also to serve as types of the selection.

The selection of the ears from the breeding-patch is continued each succeeding year as above outlined so that the method is one of continuous connected breeding and should supply seed of a gradually increasing efficiency.

The multiplication-plot of corn.

In order to obtain seed from the highly bred stock for planting the general crop it is necessary to plant a multiplication or increase-plot. To plant this plot take for seed the best remaining ears from the detasseled portion of the highest yielding rows after the select breeding

ears have been removed. The multiplication-plot should be isolated from all other corn in order to prevent deterioration by crossing with inferior strains. When the multiplication-plot is husked the best ears should be selected out by some convenient method and preserved as seed to plant the general crop. The multiplication-plot is not grown for purposes of breeding but simply to multiply the available seed of the improved variety from the breeding-plot. The breeding-plot will each year supply seed of an increasing degree of efficiency for planting the multiplication-plot and this in turn will each year supply more and more highly bred seed for the general crop.

Planting the breeding-plot in third year.

In the third and succeeding years some care should be taken in the arrangement of the rows planted from the different select ears to get rows from unrelated ears together. If for instance Row 1 was a high yielder in the breeding-patch of the second year we would probably have a number of select ears from this row and these ears would be numbered 1–1, 1–2, 1–3, etc. It would be well to arrange the breeding-patch in the third year in such a way that the rows planted from these ears are not side by side as they are from the same mother plant in the first generation of the selection and are thus closely related.

General consideration in respect to corn.

It will be seen that the above method of corn selection forms a continuous system which can be pursued year after year. If the method is followed carefully seed of a gradually increasing degree of yield efficiency and purity should be produced. The method of selection advocated has in the work conducted by the U. S. Department of Agriculture given excellent results and if carried out with intelligence and care can hardly fail to give marked improvement.

The careful selection of good ears at the time of husking, which are dried quickly and preserved properly is important where no plan of breeding is followed. The writer would urge farmers in general to give more attention to the improvement of their seed corn.

III. WHEAT IMPROVEMENT.

The extensive experience of wheat-breeders in various parts of the world have demonstrated beyond question that we can greatly improve our varieties by careful breeding. The most careful experiments in the breeding of wheat which have been carried out in this country, were conducted by Hon. W. M. Hays, now Assistant Secretary of Agriculture, while he was connected with the Minnesota Experiment Station. One of

the best of his selections, Minnesota No. 169, from a selected mother plant of Haynes' Blue Stem, cultivated for four years (1895–'98) at the Minnesota University farm, and in 1898 at Grand Rapids, Minnesota, and at the Agricultural Experiment Stations in Iowa, South Dakota, and North Dakota, gave an average yield of 24.7 bushels per acre as compared with an average yield of 21.9 bushels per acre by the parent sort, Haynes' Blue Stem, cultivated the same years at the same stations. This is an average increased yield of 2.8 bushels per acre under a very wide diversity of conditions. The average increase it should further be noted, is much greater if the yield obtained at the University farm only are considered. Here in 1895, 1896, 1897, and 1898, Minnesota No. 169 gave an average yield of 28.3 bushels per acre, while the parent sort the same years averaged only 22.5 bushels per acre, an average increase during four years of 5.8 bushels per acre. The greater yield obtained at the University farm is easily understood when it is remembered that the new strain was selected here and thus was bred to suit the local conditions. This emphasizes the necessity of conducting selection experiments with the standard races in different localities to obtain strains best adapted to the local conditions. In this regard wheat is no exception to the general rule. It has been found repeatedly with various plants that varieties originated in one locality and adapted to one set of conditions, when removed to a different locality where different conditions obtain, may give indifferent results or fail completely.

The work of selection to increase the yield and better adapt wheat to local conditions is simple so that it can readily be carried on by any intelligent grower, and the writer would urge this as a very practical and feasible line of improvement for local growers to undertake. The improvement of quality, increasing of gluten content, and the like, and hybridization experiments require considerable skill and greater facilities for testing, and so on, and probably can be successfully carried out only by those who make a specialty of such work.

Wheat is one of the most important agricultural crops in New York, but is, nevertheless, one in which we seldom find any method of seed improvement in use. About the only method used ordinarily to improve the seed is the separation of the plump and heavy seed from the poor, light seed, by some method of screening or by use of air blast separators. What is needed is the adoption generally of some systematic method of breeding which will be simple enough so that it is satisfactory for general use. Wheat is normally self-fertilized, almost no crossing occurring naturally, and it is, therefore, a very easy plant to handle in breeding as the different individuals or plots which are being grown do not require to be planted in isolated locations but can be grown together in the same field.

In the production of new varieties, the breeder would expect to use careful methods of hybridization and selection, but in general these methods are too complex for ordinary use. However, the writer believes that it is possible even for practical farmers, to produce varieties of value and to greatly improve the yield of their own crop. There are three simple methods of wheat-breeding which appeal to the writer as practical for farmers generally to undertake. One of these methods of improvement is the selection of chance variations or sports and the propagation from them of improved varieties. A second method is the systematic selection of the best yielding plants from a well known race to secure more highly productive strains, and a third method is the selection of large heads or ears for seed. Following is a discussion of these three methods.

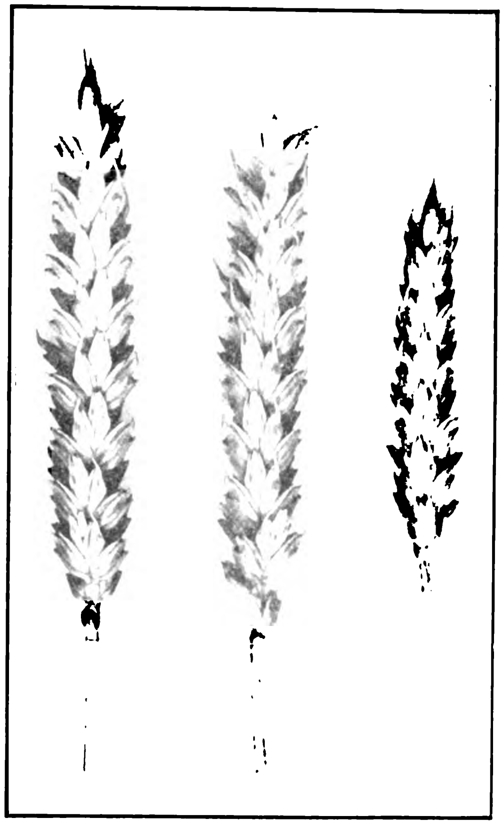


FIG. 141.—*Variations in size of heads of Gold Coin wheat. Three-fourths natural size.*

New varieties from chance variations or sports of wheat.

Selecting the good plants, first generation.—A considerable number of our best varieties or races of wheat have been produced by selecting in the field or along the roadsides, individual plants which because of their marked superiority were recognized as especially good plants and preserved for seed purposes.

Marked variations or sports possessing improved characters occasionally occur in fields of cereals and these are sometimes found by observing growers and developed by selection into valuable races.

Many of our well known races of wheat have apparently originated in this way. The Tappahannock wheat which, in 1872, was considered to be a valuable race was found in 1854 by a Mr. Boughton, of Essex

County, Virginia. The account of its discovery as given in the Report of the Department of Agriculture for 1872 is as follows: "He noticed in his field a bunch of wheat of such growth as to attract his attention * * * At harvest he found it to be a white wheat, at least two weeks earlier than the surrounding red wheat." The Fultz wheat, which is

FIG. 142.—*Good and poor heads of Seneca Chief wheat with grain from similar heads. About two-thirds natural size.*

a very popular and excellent race, grown extensivey in the eastern states, was found in 1862 in a field of Lancaster Red by a Mr. Abraham Fultz of Pennsylvania. Some beautiful heads of smooth wheat attracted his attention and they were saved and the seeds planted by themselves. These produced the wheat later named the Fultz. The American races, Wheatland Red, Pride of Butte, and Gold Coin, and the well known English races, Hopetown and Chevalier, were other acciden-

tal seeding variations. The Pride of Butte wheat, quite well known in California, was found in a field of rye and because of its extreme vigor was saved for trial. The Gold Coin wheat (Fig. 141), a seedling sport differing from the Hybrid Mediterranean in being bald and white, was found by Mr. Ira W. Green, of New York, in a field of that race and improved by selection. Mr. Green informs me that by five years of selection he succeeded in fixing the type and meanwhile increased its yield about ten per cent.

It is probable that a dozen sports or mutations of wheat plants are produced every year in New York; any one of which if observed and propagated without further selection would form valuable new varieties, possibly superior to any we now have. Only an isolated individual here and there is watching for such superior plants and testing them. Cannot more farmers be induced to familiarize themselves with the standard wheat varieties, form a critical idea of a good wheat plant, and be on the lookout for such superior plants? Almost all farmers think they know a good wheat plant but it is questionable whether many have observed the individual plants carefully enough so that they would recognize a plant having a larger number of stools than common, or exceptional yield as judged by the average size of all heads on the plant, etc. Different wheat plants and varieties should be studied till the breeder can recognize exceptional plants as to size of head, yield of grain, good quality and size of grain, number of stools, strength of straw, etc. (Fig. 142). Equipped with this knowledge, the grower is ready to search the road sides, fence corners, wheat-fields, oat-, barley- and rye-fields, indeed to be on the lookout constantly and everywhere for wheat plants showing desirable qualities. Don't wait until the wheat is mature and ready to cut before searching for such good plants. As soon as the wheat is large enough to show mature size of heads begin the search. As plants are located which appear promising, mark them or note their location so that the mature seed can be gathered later. The number of plants to be selected should be limited only by the breeder's enthusiasm and the time at his disposal. The more the better is the only instruction that can be given, as the greater number of selections made, the greater is the probability that one individual of exceptional value may be found. If possible, at least several hundred should be selected.

When the plants are ripe the seed from each plant should be gathered and preserved in separate sacks. If you have scales of sufficient fineness it would be desirable and interesting to weigh the total grain from each plant and preserve this record for future comparison. Number each selected plant by the system discussed in early part of this paper (see page 142). These plants are the first generation selections.

*Planting the selections.** Plant the seed of each plant separately in a short row by the so-called "plant-to-row-method." A satisfactory way is to place the rows one foot apart. About every twentieth row should be planted with seed of some standard variety for comparison, and it would be well also to plant rows of several other standard varieties for comparison. If the land on which the selections are planted is weedy it will require to be hoed once or twice during the spring to keep the weeds down.

When the selections begin to ripen note the season of maturing of the rows from different individuals, and when they are fully ripe go over each row carefully and study their comparative value with each other and with the rows of standard varieties planted with them. Discard all rows which are apparently inferior in yield or are badly affected with any disease, such as rust or smut or which show any noticeable tendency to lodge or shatter badly. It is highly important to secure varieties which will not winter-kill badly, and rows which are noticeably affected by winter-killing should be discarded unless the winter has been so severe that all of the progenies are badly affected. In such a case choose those injured the least. Retain the superior good rows. Each row thus selected should be examined to see that all of the plants in the row are of uniform type. If any plants in a certain row differ from the general type of the row they should be pulled out and thrown away. These rows should then be harvested separately and the seed from each preserved separately. Keep the seed numbered in accordance with the number of the individual plant first selected. Carefully preserve records of yield, earliness, hardiness, etc., of the different numbers.

Second generation.— With the seed of each selected row of the preceding year, plant a drill row 17 feet long using a definite rate of seeding; one-half ounce of seed per row would be at the rate of about one and one-half bushels of seed per acre and should be thick enough. These 17-foot rows should be planted one foot apart so that one row represents $\frac{1}{16}$ of a square rod or $\frac{1}{2560}$ of an acre. Plant as many 17-foot rows from each kind as the amount of seed obtained will plant, but if more than one row is planted place them in different parts of the field in order to obtain a better judgment of the variation due to soil. In planting the 17-foot rows at least every twentieth row should again be planted with a standard variety for comparison.

When the grain is ripe examine them as in the first generation and discard all inferior rows. Harvest and thresh each select row, keeping them separate and saving all seed of the best rows. Carefully weigh the

*The row method of testing varieties and selections described here is based on the method devised by Prof. J. B. Norton in the breeding of oats. Am. Breeders' Association Vol. III, p. 280.

grain from each row and compare the yield per row with the yields from the rows of the standard varieties and record the results. This will give an indication of the yielding capacities of the different select strains.

Third generation.—As in the preceding year plant 17-foot rows of all of the second generation rows selected and of a few of the very best and highest yielding strains plant larger plots to increase the seed for more extensive planting.

When the test rows of this year have been examined, threshed and the production per row obtained and compared with the production per row in the second generation tests, the experimenter should be in position to form a fair idea as to which strains are the best yielders. Save a few of the best for more extensive trials in the fifth year. Of some of these best strains where small increase plots were grown, there should be sufficient seed for comparatively large increase plots in the fourth generation.

Fourth generation.— Plant 17-foot test rows of the strains retained in the third generation in comparison with some standard varieties and where the seed is abundant several of these test rows should be planted in different parts of the test plot. Plant as large increase plots of the most promising strains as the seed obtained will permit.

Examine the test rows when ripe, harvest and weigh the product of each separately, as heretofore, carefully preserving the yield records. Now compare the test row and increase-plot yields of each strain for the three years with each other and with the yields of the standard varieties which also should have been retained in the test for comparison. The breeder should with the data now accumulated be able to determine whether any of his strains have yielded better than ordinary varieties and are thus valuable to retain for extensive trial. All but those which he believes to be superior to any other grown and to the standard varieties, should be discarded. It is safe at this point to discard all but two or three strains, and if only one strain is markedly superior probably all but this one should be discarded. All of the seed from test rows and increase plots of the strains finally selected should be preserved and a large field planted the next season.

If the grower has reason to believe that he has secured a superior variety of high yielding capacity he should as soon as possible have it tested by his neighbors and distribute the seed as extensively as the results obtained with the variety justify. If extensive tests prove it to be a superior variety is should be given a distinctive name so that it will not become confounded with other sorts.

The above outline is based on selecting entire plants and getting the total product of the different plants in beginning the selection. In many cases, it is found handy to simply select large, fine heads which ap-

parently represent good plants and plant the product of each head or ear in a row by itself, the same as is described for planting the individual plants, except that where heads only are selected there will not be seed enough for a 17-foot row. In this case the rows will have to be made short in accordance with the amount of seed in the head selected. Ordinarily these will furnish enough seed for one or two 17-foot rows the next generation. The further tests should be carried out exactly as described above where whole plants are selected.

Systematic selection of high-yielding varieties.

Another line of work similar to the above and which should be carried out in the different years in exactly the same way, is the selection of well-known races to secure high-yielding strains. If the farmer is growing a standard variety which he has thoroughly tested on his farm and which he knows to be well adapted to the local conditions, he may be able to secure a higher-yielding strain by selecting and testing the highest yielding plants. To carry out this work go through a field of the variety just before cutting and select out a number of the best-yielding plants. These should be harvested and the product of each plant preserved separately and planted the next year by the plant-to-row method. Carry out the test of these plants through several years exactly as described above for the selection of chance variations and sports.

Selection of large heads of wheat.

As explained in the early part of this paper, in general the individual is the unit of selection which should be followed. There is, however, considerable evidence to show that much improvement may be accomplished by the simple selection of large heads.

The simplest application of this method consists in examining a field of a good standard variety and selecting a quantity of the largest heads. To start this work well, enough heads should be selected to make at least a bushel or more of seed. Thresh this seed together and plant it in a good field the next year in an increase-plot. This if seeded fairly lightly will give a field of an acre or more.

When this increase-plot is ripe go over it again and select out enough large heads for a similar sized plot the third year. Harvest the remainder of the crop together and use the seed to plant the general crop of the third year. This method of selection should be continued year after year as a regular way of getting good seed for planting. This policy has been followed extensively in Canada and is reported as giving very satisfactory results.

IV. IMPROVEMENT OF OATS AND BARLEY.

Like wheat, oats and barley are self-fertilized plants and, therefore, do not require that the breeding-patches be isolated from the general crop. What has been said regarding the methods which can be used in wheat-breeding applies equally well to oats and barley. The breeding of oats has been much neglected and few pure bred strains exist. Varieties are frequently very much mixed with different types and growers ordinarily fail to observe this mixture. In starting the selections, therefore, the different types of heads and grain should be studied until they are familiar to the breeder in order that he may recognize impurities in the strains he is selecting and be able to weed them out. In barley also, the same statement holds true. In all cases the breeder must study the crop he is attempting to breed until he is familiar with the different types and with the market requirements.

With oats and barley, the three methods of breeding described above for wheat may be followed in every detail and thus do not need to be repeated. The breeders of these crops should examine methods described for wheat under the headings: 1, new varieties from chance variations or, sports. (This bulletin p. 315); 2, systematic selection of high-yielding varieties. (This bulletin p. 319); 3, selection of large heads. (This bulletin p. 320). In oat- and barley-breeding the attention of the breeder should primarily be directed to securing the best-yielding strains for a certain region representing a certain soil and climatic condition (Fig. 143). Increased yield of a good product is always the primary problem. Secondary problems to which a grower can give attention if desired are, season of maturity; that is producing early or late varieties and in a few instances quality of the product. In oats a large heavy

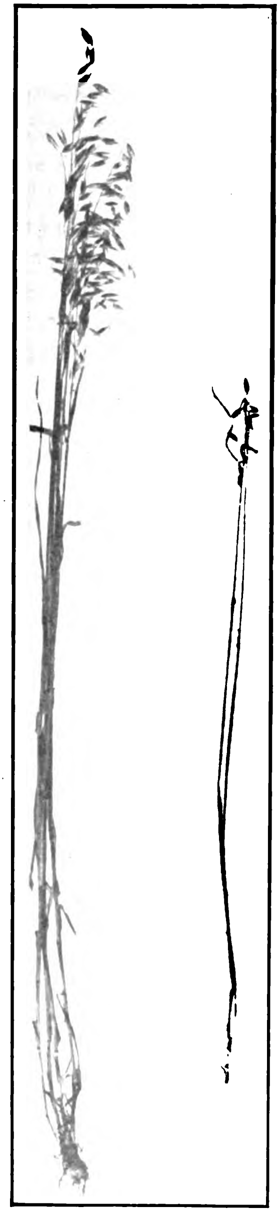


FIG. 143.—*Good and poor oat plants growing side by side in the same field.*

grain is important as otherwise the product will be too light. Again, a white oat always sells better than the black or dark colored varieties. While the color of an oat in no way affects its intrinsic value so far as we know, nevertheless the market prefers a white oat, and thus if we can get the same yield in a white oat, it is the preferable sort. The grower should always be on the lookout for diseases in his selection-patches and discard the progeny of any selection which is found to be particularly susceptible to any diseases such as rust or smut, or which shows a tendency to lodge, or to shatter. Some varieties lodge much more readily than others and this is an objectionable character. In oats in particular some strains have the grains lightly attached and as soon as they ripen the grains begin to fall. As the ripening at best is somewhat uneven, this tendency to shatter as it is called, if pronounced in a variety, may cause considerable loss.

V. METHOD OF IMPROVING POTATOES.

The potato is very extensively cultivated in New York and is one of our most important agricultural crops. In 1906, according to the statistics gathered by the U. S. Department of Agriculture, the New York acreage was 420,406 acres, which gave an average yield of 105 bushels per acre and a total crop of 44,142,630 bushels. The average valuation is given as 49 cents per bushel, at which rate the farm value of the crop in New York was $21,629,889. New York stands first among the states in potato production, both as to amount of acreage, total product and value of product. Michigan, the next largest potato-producing state, in 1906 grew 285,000 acres, which gave a yield of 27,075,000 bushels of potatoes. While New York stands first in acreage and total production, our average yield, 105 bushels per acre in 1906 and 70 bushels per acre in 1905, is low. In yield per acre, New York ranked sixteenth among the states in 1906 and forty-second in 1905. In the case of a crop of such value to the State it is important that every means be used to increase the production. Probably less attention has been given to the selection of the seed by farmers generally than to any other factor of their cultivation. The breeding of new clons or varieties of potatoes is naturally accomplished mainly by the growing of seedlings and the selection of the best, or by the hybridization of different varieties.

The majority of our ordinary varieties of potatoes, however, have lost the ability to produce fertile seeds except under rare conditions. This sterility is apparently due to the continued amelioration under continuous vegetative propagation from the tubers. The history of development of cultivated plants as a whole indicates that when a plant is propagated for many years vegetatively it gradually shows a tendency to

produce fewer and fewer seeds. This would naturally be especially true when as, in the potato, the part for which the plant is grown is not the fruit. The difficulty of obtaining seeds from our ordinary types and, furthermore, the cost and expense of growing and testing seedlings, would preclude this type of potato-breeding from being recommended as desirable for farmers generally to undertake. Fortunately, however, we have in the potato an illustration of a plant that can apparently be greatly improved by tuber or bud selection. Where a single whole tuber is planted in a hill the yield of the hill becomes a measure of the productivity of the bud which formed the seed tuber planted. Experiments which have been conducted by several investigators, have demonstrated that hills differ greatly in their productivity and that this tendency is one which is in considerable degree transmitted to the hill or tuber progeny. The most reliable results of this kind of which the writer has knowledge, are those which have been obtained by C. W. Wade of the Ohio Experiment Station, at Wooster, Ohio.[1]

In these experiments which were begun in 1903, ten high-yielding hills and twenty low-yielding hills were selected and the seed preserved separately. In 1904, ten hills each were planted from seed of the ten heavy hills and five hills each from seed of the light-yielding hills, making 100 hills of each group. To compare with these as a check, 100 hills were planted from seed which had been selected without reference to individual hills.

In 1905, 100 hills were again planted with seed from high-yielding hills and 100 hills from low-yielding hills, the seed being selected respectively from the high-yielding and low-yielding hills of the 1904 crop. A similar check to that of the preceding year was also planted. In 1906 the same policy was pursued, the results reported thus representing three years of selection. The following table quoted from Mr. Wade's report summarizes the results clearly.

SUMMARY OF RESULTS FROM USE OF SEED POTATOES FROM HIGH-YIELDING HILLS AND FROM LOW-YIELDING HILLS.

(*Variety, Carman No 3.*)

SOURCE OF SEED	YIELD OF 100 HILLS				NUMBER OF TUBERS IN 100 HILLS			
	Total 1904	Total 1905	Total 1906	Average 1904-5-6	Total 1904	Total 1905	Total 1906	Average 1904-5-6
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*				
High-yielding hills	125	173	116	138	781	865	676	774
Check-rows	115	136	79	110	713	630	479	607
Low-yielding hills	84	75	61	73	566	546	364	492

[1] C. W. Wade, "Results of Hill Selection of Seed Potatoes," American Breeders' Association, Vol. III, 191-198 (1907). See also Bull. 174, Ohio Agricultural Experiment Station.

It will be seen from this table that the average yield of the 100 heavy hills for the three years was 138 pounds against a similar average of 73 pounds for the light-yielding hills. This and other experiments indicate the importance of the hill selection of potatoes and the writer believes that breeding-work of this nature will prove very valuable for the potato-grower to pursue with the view to improving the seed primarily for his own cultivation and possibly also for sale as seed. Following is a short outline of such a method of breeding, which will serve as a guide to farmers desiring to start work of this kind.

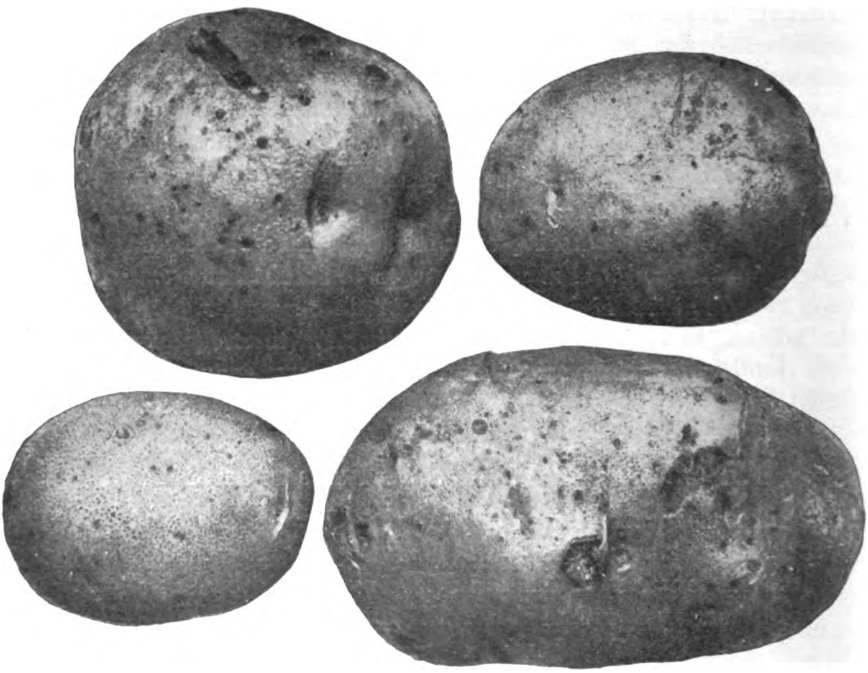


FIG. 144.— *Tubers of Rural New Yorker. Very nearly one-half natural size. Top row, left, poor-shaped spherical tuber, too large; right, good-shaped tuber of about right size. Bottom row, left, good-shaped tuber with good eyes, but too small; right, tuber too long and too large.*

Selection of foundation stock of potatoes.

Probably no crop generally grown is more influenced by environment than the potato. The experience of growers indicates that a variety found to be the best suited to the local conditions on one farm may not prove to be the variety best suited to the conditions existing on an adjoining farm. It thus becomes desirable for any farmer who is growing potatoes extensively, to test varieties sufficiently to determine which is the variety best suited for the local conditions concerned. This ordi-

narily does not require an extensive test as the experience of growers in a region has usually shown the general superiority of a comparatively few varieties and the test can thus be limited to these varieties which in general are known to be the best. The writer would not urge this test of varieties, if it were not very important to begin any breeding-work with the best variety available. Breeding-work requires so much attention, that it does not pay to start work with an inferior variety. The first work of anyone contemplating breeding with potatoes is thus, determining the best foundation stock to use for the selection work. If the grower has had extensive experience in growing potatoes and has determined that a certain variety gives the best results under his conditions, he is in position to start the selection work without a further test of varieties.

Growing potatoes for selection.

The influence of the number of eyes and size of piece planted as seed has so much to do with the yield of the hill that fields planted in the ordinary way are very poorly adapted to begin the work of selection. It is of primary importance that the first selections made be of the very highest type obtainable, as it is a common experience that the first selection is the most important. Too much attention cannot be given therefore, to the first selection. The writer would thus urge the following method as one of the most satisfactory to be pursued:

(1) Examine a large number of tubers of the variety selected as the foundation stock and decide on the most desirable shape and type of tuber. In general a moderately large tuber, which is oblong or somewhat cylindrical in shape and oblong in cross section is considered most desirable (Fig. 10). A spherical tuber if sufficiently large to be desirable is so thick that in cooking, the outside is liable to become over done before the interior is properly cooked. A tuber with shallow eyes, netted surface and white color, is also usually preferred.

(2) When the ideal character and size have been determined, examine a large number of tubers and pick out a thousand or more having this size, shape and general character. This is work that can be done in the late fall and winter when there is no rush of other farm work, and time should be taken to obtain a considerable number of these tubers of the same character. These are to be used as the seed for planting the selection-plot and the number selected should correspond to the size of the plot which it is desired to plant, four hills being planted with each tuber. There should certainly not be less than 1000 and a much larger number is very desirable. The prospective breeder should remember that success in breeding-work depends upon selecting the one individual that gives the very highest yield possible under the conditions, and the

larger the number of individuals examined the more likely is he to discover the one producing the maximum yield which will give a valuable new strain. There is no loss in growing the selection-plot aside from the greater amount of time required for the digging so that one should grow a considerable number of plants.

(3) The planting should be arranged in such a way as to secure a test of the productivity of each tuber. To do this the following method may be recommended. Cut each tuber into four uniform sized pieces making each cut longitudinally so that each piece will contain an equal proportion of the basal end and apical end of the tuber. Plant four hills with each tuber, one piece in a hill. These should be planted consecutively in each row beginning at one end, so that starting at that end the first four hills will be from one tuber, the second four hills from another and so on throughout the length of the row. The object in planting this way is so that the four hills can be dug together and the total product weighed to obtain a measure of the productivity of the seed tuber planted. Probably the best way to plant these is to drop the selected tubers one to each four hills and then go over the row and cut each tuber and plant its quota of four hills. The hills in the row should be planted somewhat farther apart than in ordinary planting, probably from 20 to 24 inches. If this is not done a somewhat greater distance than ordinary should be left between each four-hill tuber-unit. The writer would advise that one hill be left unplanted between each four-hill unit. It would doubtless be convenient and desirable to have the plants in rows both ways to facilitate digging. For this selection-plot of potatoes, choose a field of moderately good fertility and as uniform throughout in soil as is possible to obtain.

(4) Manure and cultivate the plot of potatoes grown for selection exactly the same as you do your ordinary crop.

How to make the selections of potatoes.

Field examination.—A careful examination of the selection-field should be made as the vines begin to mature and while they are yet green. This examination should include observations on diseases and vigor of the tops. If there are any marked differences apparent between the different four-hill units, those with the best appearing, most healthy tops should be marked by small stakes which can be stuck in the ground beside the hills. This field examination while probably important in careful work could probably be omitted without very great loss, as after all the yield is the primary character.

Digging the selection-field.—The digging of the field grown for selection purposes requires considerable care, and here hand work is necessary. Dig each four-hill unit grown from the same tuber separately.

being careful to get all of the product and avoid cutting or injuring the tubers as much as possible. Carefully place the product of each four-hill tuber-unit together at one side of the row, and if it is a tuber-unit marked with a stake in the field examination, keep the stake with the product of the unit. A good way to dig the field to avoid getting the hills of the different tuber-units mixed, is to dig across the field, in a direction at right angles to the direction the rows were planted. First dig the four hills of the first tuber planted in the first row, then the four from the first tuber in the second row, then the same in the third row, fourth row, etc., through the field. Next dig the four hills from the second tuber planted in the first row, then the four from the second tuber in the second row, etc. By this method of digging especially if the hills are rowed both ways, there will be little danger of mixing the product of the four-hill units.

Making the selections.— The problem now is to select out from fifty to one hundred of the best tuber-units. Best, that is, in yield, uniformity of product, color, shape, etc. After the potatoes are dug and the product of each tuber unit is laid out separately, the real work of selection begins. The following are the important steps in this process:

(1) Go over the field and study the tuber-units in a gross way until you have well in mind the variations in yield and the general uniformity of the tubers in the various tuber-units. Remember that total yield is not the only important character. What one wants is to discover those tuber-units which have the largest yield of good merchantable potatoes of the best shape and appearance. Size up the field as a whole with reference to these characters.

(2) Go over each row carefully and throw out all of those tuber-units which can be clearly seen to be inferior. These can be thrown together and placed with the general crop of potatoes. For the interest of the grower, however, it would be well to weigh the product from some of the light yielding tuber-units and preserve the figures as a matter of showing the extent of variation occurring. By this first discarding process the number of tuber-units will probably have been reduced to two or three hundred. It is very probable that in some cases that one or more of the hills of a four-hill tuber-unit will not grow. In such cases the tuber-unit will have to be judged in proportion to the number of hills actually grown.

(3) Now, provide yourself with scales of some handy pattern like the ordinary counter scales used by grocers, with which the product of each tuber-unit can be easily and quickly weighed. A satisfactory scale should weigh accurately to at least a half ounce. Weight the product of the remaining tuber-units, examine the tubers more carefully as to their character and uniformity of size in the tuber-unit and

select about fifty of the best units. These fifty units should naturally be from those marked as having good healthy vines in the first examination, before digging, unless all of the vines at that time were in fairly good condition. In making these final selections if some hills in a tuber-unit are missing the comparative yield can be easily calculated. If one hill is missing a comparative yield for four hills in obtained by increasing the weight from the three hills by one third. If two hills are missing a comparative yield for four hills would be double that obtained from the two hills. If more than two hills are missing discard the unit entirely.

The product of the tuber-units selected should then be placed in paper bags, the product of one tuber-unit only being placed in a bag. A good bag for the purpose is the twelve pound manilla paper bag used by grocers. Number each tuber-unit consecutively and place this number on the bag. In your notebook record under the number of each tuber-unit, the number of large, medium sized, and small tubers and the total weight of the product. The bags containing the seed should then be placed in suitable storage where they will not be torn and the tubers mixed. The tubers from the best discarded tuber-units should be retained to plant the general crop the next year.

If at digging time the grower is crowded with work and wishes to save time, the two or three hundred tuber units retained after the first gross selection (see paragraph 2 above), could be placed in paper bags and the more careful examination and weighing of the product delayed until some convenient time during the winter when the final selection could be made. The 12 pound paper bags of good quality should cost only about 40 cents per hundred. If the 12 pound paper bag is too small use a 16 pound bag.

Selecting seed for the second year's planting.

Some time during the winter or at any convenient period before planting time carefully examine the product of each select tuber-unit and pick out the ten best tubers of each as judged by the ideal standard of a good tuber which has been taken as the type of the selection. The ten best of each retain in the numbered sacks for planting and discard the remaining tubers.

Second year's planting.— In the further handling of the selections made the first year the planting the second year must be arranged in order to test the productive power of each of the fifty select tuber-units. Plant each tuber-unit in a row by itself by the same method used in planting the first year's crop (see p. 165). That is, plant four hills with each tuber cutting the tuber longitudinally into four equal sized quarters, making each cut from base to apex of the tuber. As ten select tubers were retained from each tuber-unit this will make forty hills per row

and if fifty tuber-units were selected there will be 500 tubers to plant which will make a total of 2000 hills in the breeding-plot. The land used for this breeding-plot should be carefully selected for uniformity, as variations in the land will modify the comparative yield and is liable to render the results untrustworthy. Number each row of forty hills with the number given the tuber-unit of the preceding year. It is desirable for comparison to plant about every tenth row with unselected seed of the same variety, cut and planted in the same way, but without reference to keeping each tuber separate. The production of these check-rows will show whether progress is being made in the selection.

Cultivate the breeding-plot and treat it otherwise just as an ordinary crop is treated.

Making the second year's selections.—When the breeding-plot nears maturity the individuals should be examined and either the best and healthiest vines marked, or if easier, the diseased vines showing weakness marked, so that they can be discarded later. Then dig each tuber-unit as in the preceding year placing the tubers from each four-hole unit together at the side of the row. Each unit should then be weighed and the number of large, medium and small sized tuber recorded. This will enable the breeder to determine which of the original fifty tuber-units selected in the first year has given the largest average yield in the ten tuber-units or forty hill test, and this is the primary test of the value of the original selection. Following the same method as used the first year, select from the breeding-plot the fifty best tuber-units, and preserve the tubers of each unit separately in a paper bag. The majority of the selection in this year should naturally be made from those rows which have given the highest yield. Number the tuber-units selected in this second generation 1–1, 1–2, 1–3, and 2–1, 2–2, etc., according to the scheme of numbering individual selections described in early part of this bulletin, page 142. These numbers can be placed on the bags and notes on weight of yield, number of tubers per unit, etc., recorded under the same number.

All of the good tubers from the remaining tuber-units of the breeding-plot not selected should be retained for planting a mutiplication-plot the third year which should furnish sufficient seed for planting the general crop for the fourth year.

At some convenient period, before planting time, as in the preceding year go over the product of each select tuber-unit and pick out the ten best tubers of each for the next year's planting.

Third year's selections.—In the third year, the fifty selections of heavy yielding tuber-units should be planted by the same methods used the second year, forty hills at least of each selection being planted. The row from each unit should be plainly labeled or otherwised marked to avoid mixing the pedigree. Treat this breeding-plot as described for the

breeding-plot in the second year, weigh up the product of each four-hill tuber-unit in the same way to determine which unit of the second year's selections has transmitted in greatest degree the tendency to yield heavily. Finally, select again the fifty best tuber-units to continue the breeding, and retain the good tubers of discarded units to plant a multiplication-plot in the fourth year. The numbering of the units in this year can be continued according to the same policy.

In the third year, a multiplication-plot should be planted with the good tubers from the discarded tuber-units of the breeding-plot of the second year. In planting this plot, the grower can use any method of cutting and planting the tubers which he thinks most desirable. This plot should give enough seed to plant a fairly large plot in the fourth year.

Fourth year's selections.— In the fourth and succeeding years the selection should be carried on by the same plan as outlined above. When this system is well under way, it will be seen that each year the breeder is growing a small breeding-plot, a larger multiplication-plot for seed purposes and a general crop.

Further considerations.—As the selection progresses many of the strains from the original fifty tuber-units will be entirely discarded. the breeder must be continuously watching for the appearance of heavy yielding strains and if such a strain is discovered all of the further selections should be made from this strain. Such a strain is well illustrated in the selection from heavy yielding hills made by Wade. The following table showing Wade's results is very interesting:

YIELDS (BY WEIGHT) FROM SEED SELECTED FROM HIGH-YIELDING HILLS.

(*Variety, Carman No. 3.*)

Yields of groups of 10 hills each grown from original hills or from their products.

HILL No.	Yield of selected hills, 1903		Total for 10-hill group, 1904		Total for corresponding 10-hill groups, 1905*		Total for corresponding 10-hill groups, 1906*		Average 10-hill groups, 1904-5-6	
	Lbs.	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*
1	2	8.0	13	12.0	16	3.0	9	4.8	13	1.3
2	2	13.0	15	4.5	15	9.0	9	0.5	13	4.7
3	2	10.5	12	1.5	18	3.0	10	14.0	13	11.5
4	2	2.5	11	15.0	17	11.0	11	1.8	13	9.3
5	2	3.0	12	8.5	16	9.0	11	10 3	13	9.3
6	2	1.0	10	9.5	15	0.0	14	3.3	13	4.2
7	3	1.0	13	8.5	18	7.0	15	11.0	15	14.3
8	2	7.0	10	11.5	18	1.0	13	4.3	14	0.3
9	2	1.5	12	14.5	19	10.0	11	6.0	14	10.2
10	1	14.0	12	0.5	18	8.0	10	5.0	13	9.8
Totals	....		125	6.0	173	13.0	116	13.0	....	

* Average yield of original and duplicate tests.

By examining the table it will be seen that hill No. 7 which had the highest yield of the original ten hills selected, in each of the three years during which the selections continued, gave a very high yield, and the highest average yield of any for the three years. This strain would seem to possess unquestionable merit and to be one to propagate from.

In advocating the selection of but fifty tuber-units and the planting of ten tubers only from each select unit the writer has had in mind the reduction of the work to a comparatively simple plan which would be possible of execution by many growers. It would unquestionably be better to handle larger numbers if the grower is so situated that he can take the time for it. It is, however, better to use comparatively small numbers carefully than to attempt to handle large numbers and find the work too extensive. The plan provides, however, for testing the yield of 500 tubers each year and this number should give opportunity to secure good selections. The method of selection here proposed, which Professor J. B. Norton has aided the writer in devising, is based on the tuber and its yielding capacity as a unit. It is somewhat different from any method which has been used heretofore, and is somewhat complex. It is primarily the same as the ordinary hill selection, but is believed to furnish a more accurate method of judging the yielding capacity of the mother tuber which is fundamentally what the hill selection is supposed to do. The difficulty in cutting uniform sized pieces with eyes equally favored renders the ordinary hill method very unreliable for general use, and the tuber-unit plan is believed to avoid this difficulty.

SOME IMPORTANT BOOKS AND BULLETINS ON SUBJECTS DISCUSSED IN THIS BULLETIN.

On the principles and methods of breeding.

Bailey, L. H. Plant-breeding. 4th edition. New York, Macmillan & Co. 1906.

De Vries, Hugo. Plant-breeding. Chicago, Open Court Publishing Co. 1907.

Davenport, E. Principles of Breeding. Boston, Ginn & Co. 1907.

East, E. M. The Relation of Certain Biological Principles to Plant-breeding. Bull. 158. Connecticut Agric. Exp. Station. New Haven, Conn.

Hays, W. M. Plant-breeding. U. S. Department of Agric., Div. Veg. Phys. and Path. Bull. 29. 1901.

Hunt, T. F. The Cereals in America. New York, Orange Judd Co. 1906.

Webber, H. J. Improvement of Plants by Selection. Yearbook U. S. Dept. of Agric. 1898 pp. 355-376.

American Breeders' Association, Reports Volumes I, II, and III, Washington, D. C. (Copies of these reports can be secured at $1.00 per volume from Hon. W. M. Hays, Secretary, Washington, D. C.).

On corn-breeding.

Hartley, C. P. Improvement of Corn by Seed Selection. U. S. Dept. Agric. Yearbook 1902 pp. 539-552.

Hartley, C. P. Production of Good Seed Corn. U. S. Dept. Agric. Farmers. Bull. 229 (1905).

Illinois Experiment Station, Urbana, Illinois.

Bull 53.—The Chemistry of The Corn Kernel. By C. G. Hopkins.

Bull. 55.—Improvement in The Chemical Composition of The Corn Kernel. By C. G. Hopkins.

Bull. 63.—Seed Corn and Some Standard Varieties for Illinois. By A. D. Shamel.

Bull 82.—Methods of Corn-Breeding. By C. G. Hopkins.

Bull. 87.—The Structure of The Corn Kernel and The Composition of Its Different Parts. By C. G. Hopkins, L. H. Smith and E. M. East.

Bull. 100.—Directions for The Breeding of Corn, Including Methods for the Prevention of Inbreeding. By C. G. Hopkins, L. H. Smith, and E. M. East.

Indiana Experiment Station, Lafayette, Indiana.

Bull. 105.—Corn Improvement in Indiana. By A. T. Wiancko.

Bull. 110.—Corn Improvement. By A. T. Wiancko.

Iowa Experiment Station, Ames, Iowa.

Bull. 68.—Selecting and Preparing Seed Corn. By P. G. Holden et al.

Bull. 77.—Selecting and Preparing Seed Corn. By P. G. Holden.

Ohio Experiment Station, Wooster, Ohio.

Bull. 140.—The Corn-Crop. By C. G. Williams.

Circular 42.—Pedigree Seed Corn. By C. G. Williams.

Circular 53.—Experiments with Corn. By C. G. Williams.

American Breeders' Association, Reports Vols. I, II and III See articles by J. Dwight Funk, C. P. Hartley, C. G. Hopkins, C. G. Williams.

On wheat-breeding.

Carleton, M. A. The Basis for The Improvement of American Wheats. U. S. Dept. Agric., Div. Veg. Phys. and Path. Bull. 24 (1900).

Hays, W. M. and Boss, A. Wheat: Varieties Breeding and Cultivation. Bull. 62, Minn. Agric. Exp. Sta., St. Anthony Park, Minnesota.

Hays, W. M. Plant-breeding. U. S. Dept. Agric. Div. Veg. Phys. and Path. Bull. 29 (1901).

Lyon, T. L. Improving the Quality of Wheat. U. S. Dept. Agric. Bureau Plant Industry Bull. 74 (1905).

American Breeders' Association, Reports I, II and III, see articles by M. A. Carleton, Alvin Keyser, C. A. Zavitz and T. L. Lyon.

On oat-breeding

Carleton, M. A. Improvement of The Oat Crop. 14 Biennial Report Kansas State Board Agriculture pp. 32–42.

Norton, J. B. Notes on Breeding Oats. Am. Breeders' Assoc. Vol. 3. pp. 280-285.

On potato-breeding.

Fraser, Samuel. The Potato. N. Y., Orange Judd Co. 1905.

Wade, C. W. Results of Hill Selection of Seed Potatoes. Am. Breeders' Assoc. Vol. 3, pp. 191–198. Also Bull. 174 Ohio Agric. Exp. Sta., Wooster, Ohio.

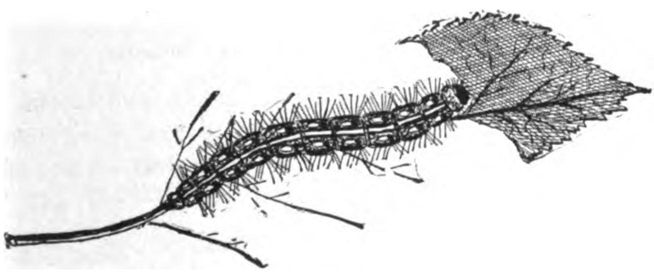
(To obtain copies of Yearbooks, Bulletins, etc., published by the Department of Agriculture, which in general are distributed free of cost, write to the Honorable Secretary of Agriculture, Washington, D. C. Bulletins of the State Experiment Stations can usually be obtained free of charge by addressing the Directors of the Stations. The location of each station mentioned is given in the above list.)

MARCH, 1908 BULLETIN 252

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE

Departments of Horticulture, Entomology and Plant Pathology

INSECT PESTS AND PLANT DISEASES



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The regular bulletins of the Station are sent free to persons residing in New York State who request them.

I. SPRAYING.

JOHN CRAIG.

The " Spray Calendar " originated at the Cornell Agricultural Experiment Station. In 1894, Prof. M. V. Slingerlands devised the first tabular calendar arrangement of spraying suggestions; this was printed and used at Farmers' Institutes. In February 1895, this Experiment Station published a " Spray Calendar " prepared by E. G. Lodeman, late instructor in the Department of Horticulture. Since that time, the spray calendar has appeared in many forms and under the authority of many writers and institutions. The Cornell publication has been changed from the chart to the pamphlet form.

Every year there is a distinct demand for the type of information furnished by this calendar. Fruit-growers and farmers realize more clearly when planting season comes that success depends as much upon the application of intelligent methods to the combating of plant parasites as upon the management of the soil.

The Need of Spraying.

The annual loss arising from the incursions of destructive insects in the United States exceed by many times the yearly output of all the gold mines in the United States. The reduction in the value of the apple crop of New York State due to insect injury, cannot be less than thirty per cent per year. This is a heavy tax on the fruit-grower. The injury, however, could be lessened at least fifty per cent by an expenditure of not exceeding two per cent on the value of an average apple crop. The need for spraying is therefore evident. This need will probably increase as time goes on.

The Principles of Spraying.

Plants, unlike animals, are not cured of diseases by medical treatment. Moreover, they cannot be made immune to insect or fungous attacks by previous treatment. We aim by spraying to *protect* plants from two classes of enemies, insects and fungi. We merely protect plants; we do not cure them. How are they protected? By covering the foliage with a medium in which the fungus will not grow, in the case

of the plant parasite; by poisoning the leaf-eating insect, or killing the sucking insect with something which destroys its body, in the case of insects.

Cornell spray calendars have stated that spraying is a type of orchard insurance. Growers ask: Shall I spray when I have little or no fruit? The answer is: Yes, by all means. Insure for your trees a crop of healthy leaves, so that wood may be grown and fruit buds developed. This is the best way to secure a crop the following year. The man who sprays year in and year out insures his crop against standard enemies, and to a large degree against epidemics, and tends to lessen the numbers of his staple insect foes.

Fig. 145. *Slugs of the potato beetle. Chewing insects.*

How to Spray.

First, know the enemy. Study the crops you are growing, and you will learn to recognize the parasites that attack them. Learn the feeding habits of these and the principal facts of their life-history. Then study the remedy, understand its principles — how it acts. Next, secure the appliance which seems best adapted to your needs. Prepare your spray mixture carefully, and apply it thoroughly. Next to timeliness, thoroughness is of prime importance. Hundreds of fruit-growers and farmers waste time, energy and material by indiscriminate and hasty squirting of spray mixtures over fruit trees and farm crops. Remember that the principle is protection, and that the plant is protected only when it is completely covered. Some insects must be hit to be killed. Do not spray, therefore, unless you do the work thoroughly for you will disgust yourself and destroy your neighbor's faith in the treatment. Spraying is not pleasant work but fruit-growers and farmers must accept the situation and make the best of it.

In the succeeding pages of this bulletin, the subjects of formulas, machinery, insects and diseases are treated. Each division has been

prepared by an authority in that particular field. Study and follow the directions carefully, apply the remedies in time and with thoroughness, and in case of failure or difficulty write to the Cornell Agricultural Experiment Station for assistance.

II. INSECTS AND THEIR CONTROL.

M. V. SLINGERLAND AND C. R. CROSBY.

For purposes of control, insects are divided into two great classes:

A. *Chewing insects,* or those having jaws by means of which they bite off and eat portions of the tissues of the plant. Examples: Potato beetle, (Fig. 145) canker-worm and codling-moth caterpillar.

B. *Sucking insects,* or those furnished with a beak containing four bristles united into a slender tube. The bristles are inserted into the plant and through them the insects suck out the sap. Examples: Squash stink-bug, San José scale and plant-lice (Fig. 146).

Fig. 146. *A plant-louse, one of the sucking insects, showing the beak.*

Chewing insects are usually controlled by applying to their food poisons such as Paris green, arsenate of lead or hellebore. *Sucking insects* cannot be reached in this way and must be killed by a direct application of contact insecticides, such as soaps, oils or other substances. In fighting sucking insects, thorough and skillful work is required since every individual insect must be hit by the spray, while in the case of chewing insects, it is merely necessary to apply the poison thoroughly to the food-plant.

APPLE.

Bud-moth. The small brown caterpillars with a black head devour the tender leaves and flowers of the opening buds in early spring. Make two applications of either 1 lb. Paris green or 4 lbs. arsenate of lead in 100 gals. of water; the first when the leaf-tips appear and the second just before the blossoms open. If necessary, spray again after the blossoms fall. For use with Boredaux, see APPLE SCAB, Cornell Bulletin 107.

Canker-worms. These caterpillars are small measuring-worms or loopers that defoliate the trees in May and June. The female moths are wingless and in late fall or early spring crawl up the trunks of the trees to lay their eggs on the branches. Spray thoroughly once or twice, before the blossoms open, with 1 lb. Paris green or 4 lbs. arsenate of lead in 100 gals. of

water. Repeat the application after the blossoms fall. Prevent the ascent of the wingless females by means of sticky bands or wire-screen traps.

Codling-moth. (Fig. 147)

This is the pinkish caterpillar which causes a large proportion of wormy apples. The eggs are laid by a small moth on the leaves and skin of the fruit.

Most of the caterpillars enter the apple at the blossom end. When the petals fall the calyx is open (Fig. 148), and this is the time to spray. The calyx soon closes and keeps the poison inside ready for the young caterpillar's first meal (Fig. 149). After the calyx has closed, it is too late to spray effectively. The caterpillars become full grown in July and August, leave the fruit, crawl down on the trunk, and there most of them spin cocoons under the loose bark. In most parts of the country there are two broods annually.

Fig. 147. *Codling-moth caterpillar in the apple.*

Immediately after the blossoms fall spray with 1 lb. Paris green or 4 lbs. arsenate of lead in 100 gals. of water. Repeat the application 7 to 10 days later. For use with Bordeaux see APPLE SCAB. Use burlap bands on trunks, killing all caterpillars

Fig. 148. *Just right to spray. Two apples from which the petals have just fallen. Note that calyx lobes are widely spread.*

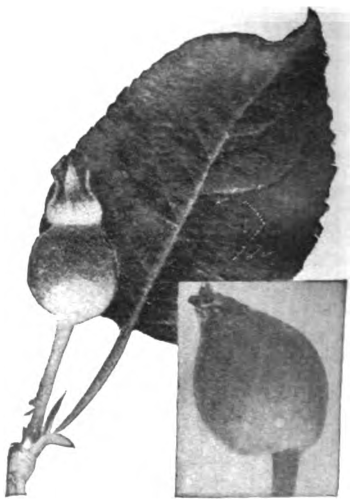


Fig. 149. *Almost too late to spray effectively. Note that the calyx lobes are nearly together.*
Egg of codling-moth on young apple.

under them every ten days from July 1st, to August 1st, and once later before winter. Cornell Bulletin 142.

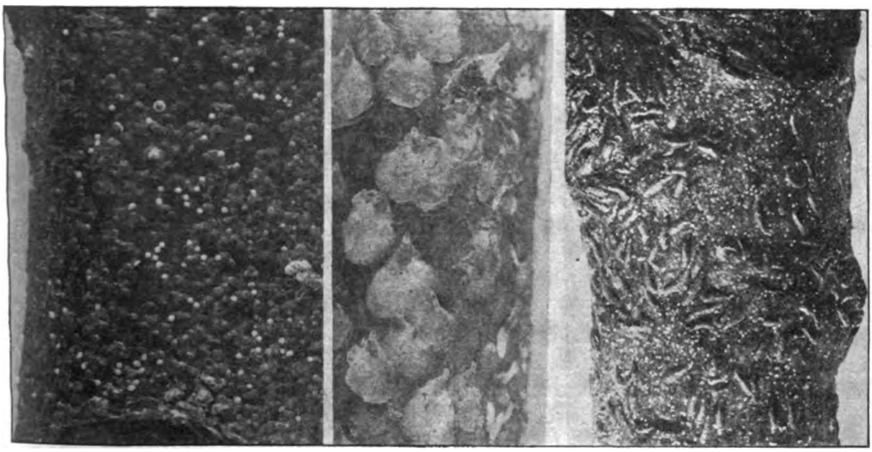
Apple-maggot or "Railroad-worm."

The small white maggots make brownish winding burrows in the flesh of the fruit, particularly in summer and early fall varieties. This insect cannot be reached by a spray as the parent fly inserts her eggs under the skin of the apple. When full-

grown the maggot leaves the fruit, passes into the ground and there transforms inside a tough, leathery case. Cultivation has been found to be of no value as a means of control. The only effective treatment is to pick up all windfalls every two or three days and either to feed them out or to bury them deeply, thus killing the maggots.

Case-bearers. The small caterpillars live in pistol — or cigar-shaped cases, about ¼ inch long, that they carry around with them. They appear in spring on the opening buds at the same time as the bud-moth and may be controlled by the same means. Cornell Bulletins 93 and 124.

San Jose scale. This scale is nearly circular in outline and about the size of a pin head (Fig. 150). When abundant it forms a crust on the branches and causes small red spots on the fruit. It multiplies with marvelous rapidity, there being three or four broods annually and each mother scale may give birth to several hundred young. The young are born alive and



San Jose Scale. Scurfy Scale. Oyster Shell Scale.

Fig. 150. *The three common scales infesting the apple.*

breeding continues until late autumn when all stages are killed by the cold weather except the tiny half-grown, black scales many of which hibernate safely.

Spray thoroughly in the fall after the leaves drop, or early in the spring before growth begins, with lime-sulphur wash, or miscible oil, 1 gal. in 10 gals. of water. When badly infested make two applications, one in the fall and another in the spring. In case of large old trees, 25% crude oil emulsion should be applied just as the buds are swelling. Geneva Bulletins 262, 296 and Circular 9.

Oyster-shell scale. (Fig. 150.) This is an elongate scale, ⅛ inch in length, resembling an oyster shell in shape and often encrusting the bark. It hibernates as minute white eggs under the old scales. The eggs hatch during the latter part of May or in June, the date depending on the season. After they hatch, the young may be seen as tiny whitish lice crawling about on the bark. When these young appear spray with kerosene emulsion, diluted with 6 parts of water, or whale-oil or any good soap, 1 lb. in 4 or 5 gals. of water.

Scurfy scale. (Fig. 150.) This whitish pear-shaped scale, about $\frac{1}{8}$ inch in length, often encrusts the bark, giving it a scurfy appearance. It hibernates as purplish eggs under the old scales. Spray as recommended for oyster-shell scale.

Leaf blister-mite. The presence of this minute mite is indicated by small irregular brownish blisters on the leaves. Spray in late fall or early spring with kerosene emulsion, diluted with 5 parts of water, or miscible oil, 1 gal. in 10 gals. of water. Geneva Bulletin 283.

Round-headed borer. The only practicable method of control is to dig out the borers or to kill them with a wire.

Apple tent-caterpillar. The insect hibernates in the egg stage. The eggs are glued in ring-like brownish masses (Fig. 151) around the smaller twigs where they may be easily found and destroyed. The caterpillars appear in early spring, devour the tender leaves, and build unsightly nests on the smaller branches. This pest is usually controlled by the treatment recommended for the codling-moth. Destroy the nests by burning or by wiping out when small.

Fig. 151. *Egg-ring of apple tent-caterpillar.*

PLUM AND PRUNE.

Plum curculio. The adult is a small snout-beetle (Fig. 152) that inserts its eggs under the skin of the fruit and then makes a characteristic crescent-shaped cut beneath it. The grub feeds within the fruit and causes it to drop. When full grown it enters the ground, changes in late summer to the beetle, which finally goes into hibernation in sheltered places. Spray just after blossoms fall with arsenate of lead, 6 to 8 lbs. in 100 gals. of water, and repeat the application in about a week. After the fruit has set, jar the trees daily over a sheet or curculio-catcher and destroy the beetles. Cornell Bulletin 235.

Fig. 152. *Beetle of plum curculio. Enlarged.*

CHERRY.

Aphis. Early in the season these dark brown plant-lice curl the terminal leaves, especially of sweet cherries. Spray with kerosene emulsion diluted with 6 parts of water. Repeat the application if necessary.

Plum curculio. See under PLUM.

QUINCE.

Quince curculio. This curculio is somewhat larger than that infesting the plum and differs is its life-history. The grubs leave the fruits in the fall and enter the ground where they hibernate and transform to adults the next May, June or July, depending on the season.

When the adults appear jar them from the tree onto sheets or curculio-catchers and destroy them. To determine when they appear jar a few trees daily, beginning the latter part of May. Cornell Bulletin 148.

San Jose scale. See under APPLE.

Round-headed apple-tree borer. See under APPLE.

PEACH AND APRICOT.

Peach borer. The adult is a clear-wing moth. The larva burrows just under the bark near or beneath the surface of the ground; its presence is indicated by a gummy mass at the base of the tree (Fig. 153). Dig out the borers in June and mound up the trees. At the same time, apply gas-tar or coal-tar to the trunk from the roots up to a foot or more above the surface of the ground. Cornell Bulletins 176 and 192.

Plum curculio. See under PLUM.

San Jose scale. See under APPLE.

Fig. 153. *Peach borer.*

PEAR.

Pear psylla. These minute, yellowish, flat-bodied, sucking insects are often found working in the axils of the leaves and fruit early in the season. They develop into minute, cicada-like jumping-lice. The young psyllas secrete a large quantity of honey-dew in which a peculiar black fungus grows, giving the bark a characteristic sooty appearance. There may be four broods annually and the trees are often seriously injured. After the blossoms fall, spray with kerosene emulsion, diluted with 6 parts of water, or whale-oil soap, 1 lb. in 4 or 5 gals. of water. Repeat the application at intervals of from 3 to 7 days until the insects are under control. Cornell Bulletin 108.

Leaf blister-mite. See under APPLE. On pears, the lime-sulphur wash has also been found effective.

San Jose scale. See under APPLE.

Codling-moth. See under APPLE.

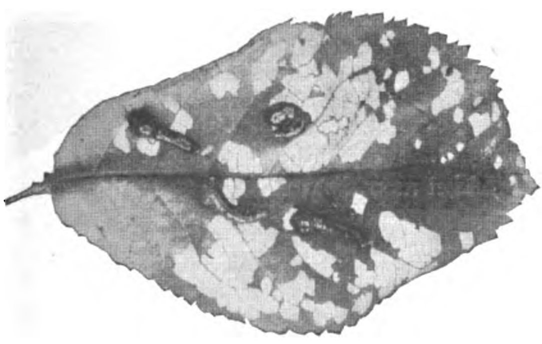


Fig. 154. *Pear slugs skeletonizing the leaf.*

Pear slug. These small, slimy, slug-like, dark green larvae (Fig. 154) skeletonize the leaves in June, and a second brood appears in August. Spray thoroughly with 1 lb. Paris green, or 4 lbs. arsenate of lead, in 100 gals. of water.

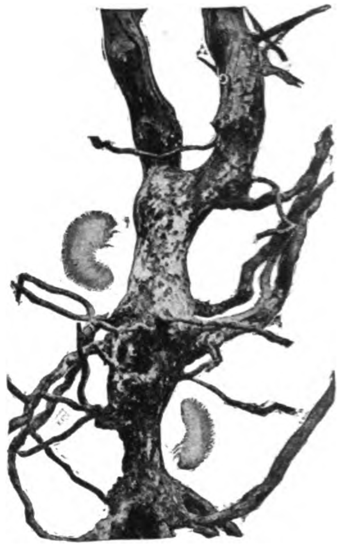


Fig. 155. *Grape root-worm.*

NURSERY STOCK.

Plant-lice. Spray thoroughly or dip the tips in kerosene emulsion, diluted with 6 parts of water, or whale-oil soap, 1 lb. in 5 gals. of water.

San Jose scale. After the trees are dug, fumigate with hydrocyanic acid gas, using 1 ounce of potassium cyanide for every 100 cubic feet of space. Continue the fumigation from one-half to three-quarters of an hour. Do not fumigate the trees when they are wet, since the presence of moisture renders them liable to injury.

GRAPE.

Flea-beetle or "Steely-beetle." The small, shining blue beetles appear in early spring and eat into the opening buds. The brown larvae feed on the leaves in May and June. When buds begin to swell cover them thoroughly with arsenate of lead, 8 lbs. in 100 gals. of water, or when beetles appear, hand-pick them into a pan containing a little kerosene. To kill the larvae on the leaves from May 15th, to July 1st, add 1 lb. Paris green or 4 lbs. arsenate of lead to every 100 gals. of Bordeaux mixture. See under BLACK-ROT. Cornell Bulletin 157.

Root-worm. The small white grubs (Fig. 155) feed upon the roots, often killing the vines in a few years. The adults are small grayish-brown beetles that eat peculiar chain-like holes in the leaves during July and August. Cultivate thoroughly in June especially close around the vines to kill the pupae in the soil. Spray thoroughly the latter part of June with arsenate of lead, 6 lbs. in 100 gals. of water, to kill the beetles. Repeat the application in a week or ten days. Cornell Bulletins 208 and 224, 235.

Fig. 156. *Currant-worms.*

Leaf-hopper. These small yellowish leaf-hoppers, erroneously called "thrips" suck the sap from the underside of the leaves causing them to turn brown and dry up. Spray the underside of the leaves very thoroughly with whale-oil soap, 1 lb. in 10 gals. of water, about July 1st, to kill the young leaf-hoppers. Repeat the application in a week or ten days. Cornell Bulletin 215.

Rose-chafer. The ungainly, long-legged, grayish beetles occur in sandy regions and often swarm into vineyards and destroy the blossoms and foliage. Spray thoroughly with arsenate of lead, 10 lbs. in 100 gals. of water. Repeat application if necessary.

RASPBERRY, BLACKBERRY AND DEWBERRY.

Saw-fly. The greenish, spiny larvae feed on the tender leaves in spring. Spray with Paris green or arsenate of lead, or apply hellebore.

Cane-borer. The larva is a grub that burrows down through the canes causing them to die. In laying her eggs, the adult beetle girdles the tip of the cane with a ring of punctures causing it to wither and droop. In midsummer cut off and destroy the drooping tips.

Fig. 157. *Rose aphis or plant-louse.*

CURRANT AND GOOSEBERRY.

Currant-worm. In the spring the small green, black-spotted larvae (Fig. 156) feed on the foliage, beginning their work on the lower leaves. A second brood occurs in early summer. When worms first appear, spray with 1 lb. Paris green or 4 lbs. arsenate of lead in 100 gals. of water. Ordinarily the poison should be combined with Bordeaux. See CURRANT LEAF-SPOT. After fruit is half grown use hellebore.

ROSE.

Aphis and leaf-hopper. The green plant-lice (Fig. 157) usually work on the buds, and the yellow leaf-hoppers feed on the leaves. Spray, whenever necessary, with kerosene emulsion, diluted with 6 parts of water, or whale-oil or any good soap, 1 lb. in 5 or 6 gals. of water.

Rose-chafer. See under GRAPE.

Rose-slug. See under PEAR SLUG.

Fig. 158. *White grub.*

STRAWBERRY.

White grubs. These large curved white grubs (Fig. 158) are the larvae of the common June beetles.

They live in the ground feeding on the roots of grasses, weeds, etc. Dig out grubs from beneath infested plants. Thorough early fall cultivation of land intended for planting will destroy many of the pupae.

POTATO.

Colorado potato-beetle. The yellow striped beetle emerges from hibernation in the spring and lays masses of orange eggs on the underside of the leaves. The larvae are known as "slugs" and "soft-shells" (Fig. 145) and cause most of the injury to the vines. Spray with Paris green 2 lbs. in 100 gals. of water or arsenate of soda combined with Bordeaux mixture. It may sometimes be necessary to use a greater strength of the poison, particularly on the older "slugs."

Flea-beetles. These small black beetles riddle the leaves with small holes and cause them to die. Bordeaux mixture as applied for potato blight protects the plants by making them distasteful to the beetles. See under POTATO BLIGHT.

CUCUMBER, MELON AND SQUASH.

Striped cucumber-beetle. These yellow, black-striped beetles appear in numbers and attack the plants as soon as they are up. Plant early squashes as a trap-crop around the field. Protect the vines with screens until they begin to run, or keep them covered with Bordeaux mixture, thus making them distasteful to the beetles.

Squash-vine borer. Squash vines are frequently killed by a white caterpillar, which burrows in the stem near the base of the plant. Plant a few early squashes between rows of the late varieties as a trap-crop. As soon as the early crop is harvested, remove and burn the vines. When the vines are long enough, cover them at the joints with earth in order to develop secondary root systems for the plant in case the main stem is injured.

Fig. 159. *Imported cabbage-worms.*

Aphis. These dark green plant-lice feed on the undersides of the leaves causing them to curl and wither. Spray with kerosene emulsion diluted with 6 parts of water. It is necessary thoroughly to cover the underside of the leaves; the sprayer, therefore, must be fitted with an upturned nozzle. Burn the vines as soon as the crop is harvested and keep down all weeds.

Squash stink-bug. The rusty-black adult emerges from hibernation in the spring and lays its eggs on the underside of the leaves. The nymphs suck the sap from the leaves and stalks causing serious injury. Trap the adults under boards in the spring. Examine the leaves for the smooth shining brownish eggs and destroy them. The young nymphs may be killed with kerosene emulsion.

CABBAGE AND CAULIFLOWER.

Cabbage-worm. The green caterpillars (Fig. 159) hatch from eggs laid by the common white butterfly. There are several broods every season. If plants are not heading, spray with kerosene emulsion or with Paris green to which the sticker has been added. If heading, apply hellebore.

Cabbage aphis. These small mealy plant-lice are especially troublesome during cool, dry seasons when their natural enemies are less active. Before the plants begin to head, spray with kerosene emulsion diluted with 6 parts of water, or whale-oil soap, 1 lb. in 6 gals. of water.

Cabbage root-maggot. The white maggots that feed on the roots (Fig. 160) hatch from eggs laid by a small fly somewhat resembling the common house fly, near the plant at the surface of the ground. Hollow out the earth slightly around every plant and freely apply carbolic acid emulsion diluted with 30 parts of water. Begin the treatment early, a day or two after the plants are up or the next day after they are set out. Repeat the application every 7 to 10 days until the latter part of May. It has also

Fig. 160. *Cabbage root-maggots.*

been found practicable to protect the plants by the use of tightly fitting cards cut from tarred paper. Cornell Bulletin 78.

ONION.

Onion thrips. Onion tops frequently turn white and die as the result of the feeding punctures caused by these minute yellowish insects. The injury is known as "white blast." Spray thoroughly with kerosene emulsion diluted with 6 parts water, or whale-oil soap, 1 lb. in 4 gals. of water.

Onion maggot. For treatment see CABBAGE ROOT-MAGGOT.

GREENHOUSE INSECTS.

White-fly. The nymphs are small greenish, scale-like insects found on the underside of the leaves; the adults are minute, white, mealy winged flies. Spray with kerosene emulsion or whale-oil soap; or if infesting cucumbers or tomatoes, fumigate over night with hydrocyanic acid gas, using 1 oz. of potassium cyanide to each 1000 cubic feet of space.

Green aphis. Spray with kerosene emulsion when practicable, or fumigate with one of the tobacco preparations. If on violets, fumigate, using ½ to ¾ oz. potassium cyanide for every 1000 cu. ft. of space and leave the gas in from ½ to 1 hour.

Black aphis. This plant-louse is harder to kill than the green aphis, but may be controlled by the same methods.

Red-spider. Syringe off the plants with clear water two or three times a week, taking care not to drench the beds.

Violet gall-fly. Violets grown under glass are often greatly injured by a very small maggot, which causes the edges of the leaves to curl, turn yellowish and die. The adult is a very minute fly resembling a mosquito. Pick off and destroy infested leaves as soon as discovered. Fumigation is not advised for this insect or for red-spider.

III. INSECTICIDES.

M. V. SLINGERLAND AND C. R. CROSBY.

Arsenate of lead. This can be applied in a stronger mixture than other arsenical poisons without injuring the foliage. It is, therefore, much used against beetles and other insects that are hard to poison. It comes in the form of a paste and should be mixed thoroughly with a small amount of water before placing in the sprayer, else the nozzles will clog. Arsenate of lead and Bordeaux mixture can be combined without lessening the value of either. It is used in strengths varying from 4 to 10 lbs. per 100 gals., depending on the kind of insect to be killed.

Paris green. This is used in varying strengths, depending on the insect to be controlled and the kind of plant treated. Mix the Paris green into a paste and then add to the water. Keep the mixture thoroughly agitated while spraying. If for use on fruit trees, add 1 lb. of quick lime for every pound of Paris green to prevent burning the foliage. For potatoes it is frequently used alone, but it is much safer to use the lime. Paris green and Bordeaux mixture may be combined without lessening the value of either and the caustic action of the arsenic is prevented.

Arsenite of soda. (For use with Bordeaux mixture only). Sal soda 2 lbs.; water 1 gal.; arsenic 1 lb. Mix the white arsenic into a paste and then add the sal soda and water and boil until dissolved. Add water to replace any that has boiled away so that 1 gallon of stock solution is the result. Use 1 quart of this stock solution to 50 gallons of Bordeaux mixture for fruit trees. Make sure there is enough lime in the Bordeaux mixture to prevent the caustic action of the arsenic.

Arsenite of lime. (For use without Bordeaux mixture). Sal soda, 1 lb., water, 1 gal. white arsenic. 1 lb., quick lime, 2 lbs. Dissolve the white arsenic with the water and sal soda as above and use this solution while hot to slake the 2 lbs. of lime. Add enough water to make 2 gallons. Use 2 quarts of this stock solution in 50 gallons of water.

Hellebore. For wet application, use fresh white hellebore, 1 oz., water, 2 or 3 gals. For dry application, use hellebore, 1 lb., flour or air-slaked lime, 5 lbs. This is a white, yellowish powder made from the roots of the white hellebore plant. It loses its strength after a time and should be used fresh. It is used as a substitute for the arsenical poisons on plants or fruits soon to be eaten.

Kerosene emulsion. Hard, soft or whale-oil soap, ½ lb., water, 1 gal., kerosene, 2 gals. Dissolve the soap in hot water; remove from the fire while still hot and add the kerosene. Pump the liquid back into itself for five or ten minutes or until it becomes a creamy mass. If properly made the oil will not separate out on cooling.

For use on dormant trees, dilute with from 5 to 7 parts of water. For killing plant-lice on foliage dilute with from 10 to 15 parts of water. Crude oil emulsion is made in the same way by substituting crude oil in place of kerosene. The strength of oil emulsions are frequently indicated by the percentage of oil in the diluted liquid:

For a 10% emulsion add 17 gals. of water to 3 gals. stock emulsion.
For a 15% emulsion add 10½ gals. of water to 3 gals. stock emulsion.
For a 20% emulsion add 7 gals. of water to 3 gals. stock emulsion.
For a 25% emulsion add 5 gals. of water to 3 gals. stock emulsion.

Carbolic acid emulsion. Soap, 1 lb.; water, 1 gal.; crude carbolic acid, 1 pint. Dissolve the soap in hot water, add the carbolic acid and agitate into an emulsion. For use against root-maggots, dilute with 30 parts of water.

Tobacco. This is a valuable insecticide and is used in several forms. As a *dust* it is used extensively in greenhouses for plant-lice, and in nurseries and about apple trees for the woolly aphis. Tobacco *decoction* is made by steeping or soaking the stems in water. It is often used as a spray against plant-lice. Tobacco in the form of *extracts, punks* and *powders* is sold under various trade names for use in fumigating greenhouses.

Soaps. An effective insecticide for plant-lice is *whale-oil soap*. Dissolve in hot water and dilute so as to obtain one pound of soap to every five or seven gallons of water. This strength is effective against plant-lice. It should be applied in stronger solutions, however, for scale insects. Home-made soaps and good laundry soaps, like ivory soap, are often as effective as whale-oil soap.

Miscible oils. There are now on the market a number of preparations of petroleum and other oils intended primarily for use against the San José scale. They mix readily with cold water and are immediately ready for use. While quickly prepared, easily applied and generally effective, they cost considerably more than lime-sulfur wash. They are, however, less corrosive to the pumps and more ageeable to use. They are especially valuable to the man with only a few trees or shrubs who would not care

to go to the trouble and expense to make up the lime-sulfur wash. They should be diluted with not more than 10 or 12 parts of water. Use only on dormant trees.

A good miscible oil can be made at home but it involves considerable labor and unless proper grades of the different materials are used there will be difficulty in combining them. Manufacturers of soaps and oils are now properly combining these materials and offering the resulting emulsifiers at reasonable prices that are considerably less than the cost of the proprietary miscible oils.

Lime and sulfur wash.

Quicklime, 20 lbs.
Sulfur (flour or flowers) 15 lbs.
Water, 50 gals.

The lime and sulfur must be thoroughly boiled. An iron kettle is often convenient for the work. Proceed as follows: Place the lime in the kettle. Add hot water gradually in sufficient quantity to produce the most rapid slaking of the lime. When the lime begins to slake, add the sulfur and stir together. If convenient keep the mixture covered with burlap to save the heat. After slaking has ceased, add more water and boil the mixture one hour. As the sulfur goes into solution, a rich orange red or dark green color will appear. After boiling sufficiently, add water to the required amount and strain into the spray tank. The wash is most effective when applied warm, but may be applied cold. If one has access to a steam boiler, boiling with steam is more convenient and satisfactory. Barrels may be used for holding the mixture, and the steam applied by running a pipe or rubber hose into the mixture. Proceed in the same manner as for boiling in the kettle until the lime is slaked, when the steam may be turned on. Continue boiling for 45 minutes to an hour, or more if necessary to get the sulfur well dissolved.

This mixture can be applied safely only when the trees are dormant,—late in the autumn after the leaves have fallen, or early in the spring before the buds swell. It is mainly an insecticide for San José scale, although it has considerable value as a fungicide for certain diseases, like the peach leaf-curl. As the San José scale is not killed unless the solution comes in contact with it, great care should be exercised to completely cover the branches.

Proprietary lime-sulfur washes are now on the market and are reported effective when used at the rate of 1 gallon of the wash to not more than 8 or 9 gallons of water.

Fumigation with hydrocyanic acid gas.

Hydrocyanic acid gas is a deadly poison and the greatest care is required in its use. Always use 98 to 100% pure potassium cyanide and a good grade of commercial sulphuric acid. The chemicals are always combined in the following proportion: Potassium cyanide, 1 oz.; sulphuric acid, 2 fluid ozs.; water, 4 fluid ozs. Always use an earthen dish, *pour in the water first,* and add the sulfuric acid to it. Put the required amount of cyanide in a thin paper bag and when all is ready, drop it into the liquid and leave the room immediately. For mills and dwellings, use 1 oz. of cyanide for every 100 cubic feet of space. Make the doors and windows as tight as possible by pasting strips of paper over the cracks. Remove the silver-ware and food, and if brass and nickel work cannot be removed cover with vaseline. Place the proper amount of the acid and water for every room in 2-gallon jars. Use two or more in large rooms or halls. Weigh out the potassium cyanide in paper bags and place them near the jars. When all is ready, drop the cyanide into the jars. beginning on the top floors, since the fumes are lighter than air. In large buildings, it is frequently necessary to suspend the

bags of cyanide over the jars by cords running through screw eyes and all leading to a place near the door. By cutting all the cords at once the cyanide will be lowered into the jars and the operator may escape without injury. Let the fumigation continue all night, locking all outside doors and placing danger signs on the house.

Fumigation of greenhouses

No general formula can be given for fumigating the different kinds of plants grown in greenhouses, as the species and varieties differ greatly in their ability to withstand the effects of the gas. Ferns and roses are very susceptible to injury, and fumigation if attempted at all should be performed with great caution. Fumigation will not kill insect eggs and thus must be repeated when the new brood appears. Fumigate only at night when there is no wind. Have the house as dry as possible and the temperature as near 60° as practicable.

IV. THE CONTROL OF PLANT DISEASES.

H. H. WHETZEL AND F. C. STEWART.

ALFALFA.

Dodder.

This disease causes small areas of alfalfa to die. Around the margins of these areas the ground is covered with a tangled mat of yellow threads that twine closely about the plants and kill them (Fig. 161). Infested spots should be closely mowed; the stubble sprinkled with kerosene, covered with dry hay and burned. Only seed free from dodder should be used. Samples of seed may be sent the Geneva Experiment Station to be examined for dodder. Alfalfa seed can be cleaned by sifting through 20 x 20 mesh sieve made of No. 34 wire. See Geneva Circular No. 8.

Fig. 161. *Dodder on alfalfa, showing the slender cord-like stems and the bunches of small white flowers.*

Leaf-spot.

This is the most serious fungous disease of the crop in the State. It causes the leaves to become spotted and yellow and to fall prematurely. New seeding when badly diseased, should be topped, *but never mowed closely.* When older fields are attacked, the hay should be cut a few days early to avoid loss of leaves and to permit a new growth that will usually outgrow the trouble. (Fig. 162.)

APPLE.

Scab. Commonly known among growers as "the fungus." Usually most evident on the fruit. Spray with Bordeaux 5-5-50 or 3-3-50; first, just before the blossoms open; second, just as the blossoms fall; third, 10 to 14 days after the blossoms fall. The second spraying seems to be the most important. Spray thoroughly. For the use of insect poisons with Bordeaux mixture, see CODLING-MOTH and BUD-MOTH. See also Cornell Bulletins 84 and 226. (Fig. 163.)

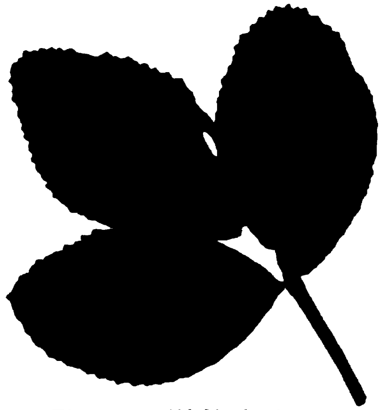


Fig. 162. *Alfalfa leaf-spot.*

Fire-blight. This is the same as Pear blight. It usually makes itself manifest on the apple trees in three forms, *blossom blight, twig blight, and blight cankers* on limbs and body (Fig. 164). This disease is caused by bacteria which are distributed by bees and flies and is not controlled by spraying. Cutting out and destroying the diseased parts are the chief measures to be taken. Cut out blighted twigs in young trees as fast as they appear. The bacteria of this disease are carried over winter in cankers on the main limbs and bodies of the trees. Remove all such cankers with sharp knife cutting well into the healthy bark and wash the wound with corrosive sublimate, 1 part to 1000 of water. Then paint the wound with heavy lead oil paint. See Cornell Bulletin, 236. Destroy or clean up all old pear and apple trees about the premises because such trees harbor the disease.

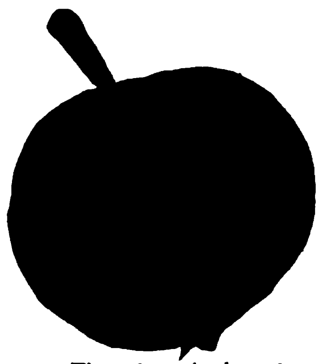


Fig. 163. *Apple-scab.*

New York apple-tree canker. This important fungous disease should not be confused with the "blight canker." Cankers are usually found on the main limbs of old trees, black and rough (Fig. 165). Canker is very common on Twenty Ounce. Since the fungus enters through wounds, avoid breaking the bark. All wounds made in pruning should be promptly painted over. Cut out cankers and treat as for "blight cankers." Spray early in spring before the buds start with Bordeaux, 10-10-50, or soak the body and the limbs when making first application for scab. See Geneva Bulletins 163 and 185.

ASPARAGUS.

Rust. The most common and destructive disease of asparagus rust produces reddish or black pustules on the stems and branches. Late in the fall, burn all affected plants. Fertilize liberally and cultivate thoroughly. During the cutting season, *permit no plants to mature* and

cut all wild asparagus plants in vicinity once a week. Rust may be partially controlled by spraying with Bordeaux, 5-5-50 containing a sticker of resin-sal soda soap (See page 202), but it is a difficult and expensive operation and probably not profitable except on large acreage. Begin spraying after cutting as soon as new shoots are 8 to 10 inches high and repeat once or twice a week until about September 15. See Geneva Bulletin 188. Dusting with sulfur has proved effective in California. See California Bulletins 165 and 172. Plant the varieties least affected by rust.

BEANS.

Anthracnose or pod-spot. A fungous disease commonly known among growers as "rust." It is carried over from one season to another in the seed. Plant clean seed obtained by selecting pods free from the diseased spots. Hand-sorting of seed, and seed treatment will not control this disease. When beans can be thoroughly hand-sprayed Bordeaux, 5-5-50, will control the trouble. Spray, first, just when the plants break through the ground; second, when first pair of leaves are expanded; third, when the pods have set. See Cornell Bulletin 239, also New Jersey Bulletin 151. (Fig. 166.)

Blight. A bacterial disease. Like the anthracnose, blight is carried over in the seed. It is difficult to control. It affects the leaves chiefly, forming large dead spots. Spraying with Bordeaux, as for anthracnose, is said to reduce the injury. See Cornell Bulletin 239 and New Jersey Bulletin 151.

Fig. 164. *Blight canker of apple.*

CABBAGE — CAULIFLOWER.

Black-rot. In this bacterial disease, bacteria get into the sap-tubes of the leaves clogging them and turning them black; the plants drop their leaves and fail to head. Practice crop rotation; soak seed 15 minutes in a solution made by dissolving one corrosive sublimate tablet in a pint of water. Tablets may be bought at drug stores. See Geneva Bulletins 232 and 251.

Club-root or club-foot. This is a slime mold disease. The parasite lives in the soil. Practice crop rotation. *Set only healthy plants.* Do not use manure containing cabbage refuse. If necessary to use infested land apply good stone lime, 2 to 5 tons per acre. Apply at least as early as the autumn before planting; two to four years is better. Lime the seedbed in same manner. See New Jersey Bulletin 98. This disease is sometimes confused with cabbage maggots, which see. (Fig. 167.)

CARNATION.

Rhizoctonia, stem-rot. The cause of this disease is a soil fungus. The plants wilt suddenly. The stem is affected with soft rot at or below the surface of the soil. In the field, change location of the plants frequently; annually, if possible. In the benches, use sterilized soil or at least use fresh soil. After transplanting into the greenhouse, keep the temperature as low as possible until the plants become established. Stir the soil frequently. Avoid over-watering. See Geneva Bulletin 186.

Fusarium, stem-rot. This is a dry rot. Plants affected by this disease die slowly, usually a branch at a time. The treatment same as for Rhizoctonia stem-rot.

Rust. This disease can be recognized by the brown, powdery pustules on the stem and leaves. Plant only the varieties least affected by it. Take cuttings only from healthy plants. Spray (in the field, once a week; in the greenhouse, once in two weeks) with copper sulfate, 1 lb. to 20 gals. of water. Keep the greenhouse air as dry and cool as is compatible with good growth. Keep the foliage free from moisture. Train the plants so as to secure a free circulation of air among them. See Geneva Bulletin 100.

Leaf-spot. Round, grayish spots on the stem and leaves are evidences of this disease. Treatment is the same as for rust.

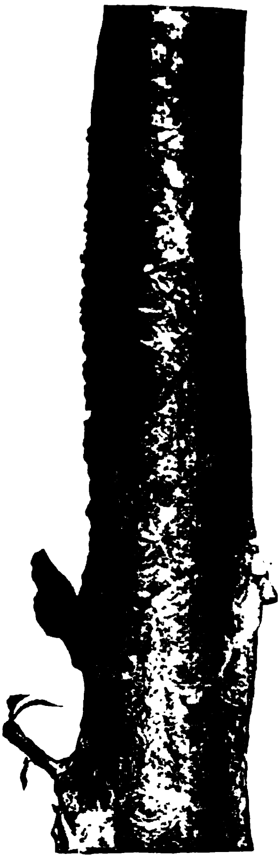


Fig. 165. *New York apple-tree canker.*

CELERY.

Cerospora, leaf-blight. This is sometimes known as "early blight." It often appears in the seed-bed and becomes destructive early in the summer. It is favored by hot weather, either wet or dry. Spray with ammoniacal copper carbonate, 6–3–45, making about five or eight applications beginning while the plants are still in the seeb-bed. Bordeaux, 5–5–50, may be used for the earlier application. Spray often enough to keep new growths of leaves covered; destroy diseased plants and refuse. See Cornell Bulletin 132.

Septoria, leaf-blight or "late blight." Leaf-blight is a fungous disease appearing late in the season. It is often destructive after celery is stored. The same treatment as for "early blight" is used except that spraying should be continued up to the time the plants are harvested. See Cornell Bulletin 132. Well-drained celery fields, half-shaded do not seem to suffer from either blight.

CHERRY.

Black-knot. A fungus, the spores of which are carried from tree to tree by the wind and thus spread the infection is the cause of this disease. The same fungus also affects plums. Cut out and burn all knots as soon as discovered. See that the knots are removed from all plums and cherry trees in the neighborhood. See Cornell Bulletin 81.

Brown-rot of fruit. Produced by the same fungus that causes the brown rot of plums and peaches. See Cornell Bulletin 98, pp. 409–410. See also Geneva Bulletin 98. See page 362.

Fig. 166. *Bean anthracnose.*

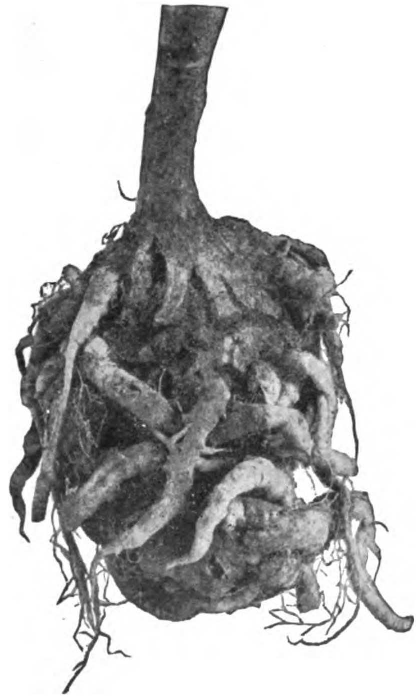


Fig. 167. *Club-root of cabbage.*

Leaf spot. This is a fungous disease in which the leaves become thickly covered with reddish or brown spots and fall prematurely; badly affected trees winterkill. Often, the dead spots drop out leaving clear-cut holes. Spray with Bordeaux, 5-5-50. Make four applications; first, just before blossoms open: second, when fruit is free from calyx; third, two weeks later; fourth, two weeks after third. See Michigan Board Agriculture Report 1906, p. 103.

Powdery mildew. It attacks leaves at the tip of the growing shoots and is often serious on nursery stock. The leaves curl and show white mealy growth of the fungus. Dust heavily with sulfur or spray with potassium sulfide, 1 oz. to 3 gals. water.

CHRYSANTHEMUM.

Septoria, leaf-spot. This is also a fungous disease. Spray with Bordeaux, 5-5-50, every ten days or often enough to protect new foliage. Ammoniacal copper carbonate may be used but it is not so effective. See Geneva Annual Report 1892, p. 558.

Rust. Treat as for leaf-spot. Avoid wetting foliage when watering.

CUCUMBER.

Wilt. This is a disease caused by bacteria that get into the sap-tubes of the leaf and stem, clogs and destroys them, causing the plant to wilt. The bacteria are distributed chiefly by striped cucumber beetles. Destroy the beetles or drive them away by thorough spraying with Bordeaux, 5-5-50. Gather and destroy all wilted leaves and plants. The most that can be expected is that the loss may be slightly reduced.

Downy mildew. This most serious fungous disease of the cucumber is known among growers as "the blight." The leaves become mottled with yellow, show dead spots and then dry up. Spray with Bordeaux, 5-5-50. Commence spraying when the plants begin to run and repeat every 10 to 14 days throughout the season. See Geneva Bulletins 119 and 156.

CURRANT.

Leaf-spots and anthracnose. This is caused by two or three different fungi. The leaves become spotted, turn yellow and fall prematurely. It may be controlled by three to five sprayings with Bordeaux, 5-5-50, but it is doubtful whether the disease is sufficiently destructive on the average to warrant so much expense. *Upon the first appearance of currant worm spray with Bordeaux and Paris green* (1 lb. to 100 gals. or arsenate of lead, 4 lbs. to 100 gals.). Repeat if a second brood of worms appears. See Iowa Bulletin 30 and Geneva Bulletin 199. (Fig. 168.)

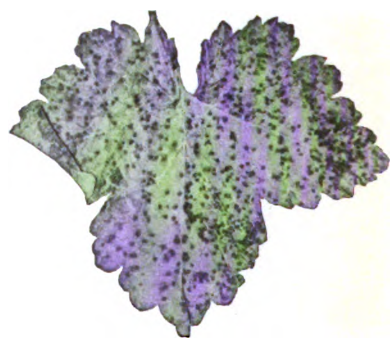


Fig. 168. *Currant leaf-spot.*

Cane-blight or wilt. Very destructive in the Hudson Valley. Canes die suddenly while loaded with fruit and leaves like those attacked by the cane borer. Caused by a fungus which kills the bark, in places and discolors the wood. No definite line of treatment has been established, but the following is suggested. Beginning when the plants are small go over the plantation three or more times every summer and cut out and burn all canes showing signs of disease. See Geneva Bulletin 1-67, p. 292.

GINSENG.

Alternaria blight. This is the most destructive and common disease of cultivated ginseng. First, spray the surface of the soil thoroughly with copper sulfate solution, 1 lb. to 10 gallons, early in the spring before the plants come through; second, spray with Bordeaux, 5-5-50, as soon as the plants begin to break through the soil. Add sticker (see page 202). Spray repeatedly while the plants are coming through the soil, making a special effort to spray the stems as it is on these that the disease first becomes established in the spring. Spray to keep plant thoroughly covered throughout the season. Spray seed heads thoroughly just after the blossoms fall and again when the berries are two-thirds grown, to prevent "blast" caused by the Alternaria fungus. Destroy diseased tops. See Special Crops, Feb. 1907, Vol. 6, No. 54, p. 22.

Wilt. A disease caused by a fungus in the sap-tubes of the root. Wilt is checked by removing the wilted plants as soon as discovered. See Cornell Bulletin 219.

Root-rots. These are caused by different soil fungi. Favored by wet soggy soils. Drain the soil thoroughly.

GOOSEBERRY.

Powdery mildew. The fruit and leaves are covered with a dirty white growth of fungus. In setting a new plantation, choose a site where the land is well underdrained and where there is a good circulation of air. Cut away drooping branches. Keep the ground underneath free from weeds. Spray with potassium sulphide, 1 oz. to 2 gals.; commence when the buds are breaking and repeat every 7 to 10 days until the fruit is gathered. Powdery mildew is very destructive to the European varieties. See Geneva Bulletins 133 and 161.

GRAPE.

Black-rot. This is the most destructive fungous disease of grapes in this state. It is carried over from one season to the next chiefly in old rotted berries or "mummies" that fall to the ground or cling to the vines. Remove all mummies that cling to the arms at trimming time. Plow early, turning under all old mummies and diseased leaves. Rake all refuse under the vine into the last furrow and cover with the grape hoe. This cannot be too thoroughly done. The disease is favored by wet weather and weeds or grass in the vineyard. Use surface cultivation and keep down all weeds and grass. Keep the vines well sprouted; if necessary sprout twice. Spray with Bordeaux mixture, 5-5-50, until the middle of July, after that with ammoniacal copper carbonate. The number of sprayings will vary with the season. Make the first application when the third leaf shows. Infections take place with each rain, and occur throughout the growing season. The foliage should be protected by a coating of the spray *before* every rain. The new growth, especially, should be well sprayed. When the foliage becomes dense the clusters should be sprayed with a "trailer" or hand-spraying device, about four applications of Bordeaux mixture and two of the ammoniacal copper carbonate will be necessary. Apply 80 to 100 gallons of spray to the acre. Use 100 to 140 lbs. pressure; use a 1-16 inch hole in the

disk of the nozzle. See Cornell Bulletin 254. For use of insecticides in Bordeaux, see "STEELY-BEETLE."

Downy mildew. This is a fungous disease most evident on the leaves making large brown spots on upper surface with white downy growth beneath. It also attacks the green fruit, causing what is known to growers as "hard white berry." Bordeaux as applied for BLACK ROT will control this disease.

LETTUCE.

Drop or rot. This is a fungous disease often destructive in greenhouses, discovered by the sudden wilting of the plants. It is completely controlled by steam sterilization of the soil to the depth of two inches or more. If it is not feasible to sterilize the soil, use fresh soil for every crop of lettuce. See Massachusetts Bulletin 69.

Fig. 169. *Ginseng blight.*

MUSKMELON.

Downy mildew. This is commonly called "blight" and is a very troublesome disease. The leaves show angular, dead brown spots then dry up and die; the fruit often fails to ripen and lacks flavor. It is caused by the same fungus as is the downy mildew of cucumbers; no effective method of control is known. While Bordeaux has proven effective in controlling the downy mildew on cucumbers it seems to be of little value in fighting the same disease on melons. See Report of Botanist Connecticut Station, 1904.

Wilt. This is same as the wilt of cucumbers; same treatment is given.

OATS.

Smut. The most common and destructive disease of oats is smut, carried over from one season to the next by fungus spores on the seed. Entirely prevented by treating the seed oats before planting with a solution of formalin, 1 pint to 45 or 50 gallons of water. Place the oats on a clean floor and sprinkle on the formalin as they are shoveled over. Use one gallon to the bushel. Mix the oats thoroughly, then shovel them into a pile and cover with blankets or canvas. After standing in the pile from two to four hours the oats, if they are to be drilled should be spread out to dry; or they may be sown by hand without drying. Use one peck more seed per acre to allow for swelling of the grain. Treatment once in three years is usually sufficient to prevent material loss from smut. See U. S. Farmers Bulletin 250 and Wisconsin Bulletin 111.

ONION.

Mildew or blight as it is commonly called is a fungous disease, much like the blight of potatoes. Spray with Bordeaux, 5-5-50, beginning when the plants show three leaves. Repeat every ten days until crop is harvested. Add one gallon sticker (see page 202) to every 50 gallons of the mixture. It is useless to begin spraying after the disease appears. See Cornell Bulletin 218.

Smut. This can be detected by the black pustules on the leaves and bulbs. It is troublesome only where onions are grown extensively; it may attack the seedlings killing them outright, or may appear on mature bulbs in fall. Onions from sets or those started in clean soil and transplanted seldom suffer. Practice crop rotation. Drill into the rows when planting seed, 100 lbs. sulfur and 50 lbs. air-slaked lime mixed, to the acre. See Geneva Bulletin 182.

PEACH.

Brown-rot is the most serious fungous disease of stone fruits in this state and one of the most difficult to control. Plant resistant varieties. Prune the trees so as to let in sunlight and air. Thin the fruit well. As often as possible pick and destroy all rotten fruits. In the fall destroy all fruits remaining on the trees and on the ground. Spray with Bordeaux mixture before the buds break. Owing to danger of injuring the foliage later applications of copper compounds are not recommended. The self-boiled lime-sulfur wash (see page 202) is now being advocated for the control of this and other diseases of peach. In some experiments carried on by the U. S. Dept. Agr. 1907 the loss from this disease was reduced from 73% on unsprayed trees to about 10% on sprayed rows. The new remedy is at least worth a trial. Spray with self-boiled lime-sulfur wash, 10-15-50. First application when fruit is about the size of the end of your thumb. Repeat every two weeks until about two weeks before fruit ripens. See American Pomological Society Report 1907, also Report Missouri Horticultural Society, 1907. (Fig. 170.)

Fig. 170. *Mummies on peach tree the result of brown-rot.*

Leaf-curl is a fungous disease in which the leaves become swollen and distorted in spring and drop during June and July. Elberta is an especially susceptible variety. Easily and completely controlled by spraying the trees once, *before the buds swell* with Bordeaux, 5-5-50, or with the lime-sulfur mixtures used for San José scale (see under fungicide). See Cornell Bulletins 164 and 180, Michigan Special Bulletins 27 and 30. Copper

sulfate 2 lbs. to 50 gals. water is also effective. The addition of lime, however, makes it easy to tell where the spray has been applied.

Black-spot or scab. This often proves troublesome in wet seasons and particularly in damp or sheltered situations. While this disease attacks the twigs and leaves it is most conspicuous and injurious on the fruit where it appears as dark spots or blotches. In severe attack, the fruit cracks. In the treatment of this disease, it is of prime importance *to secure a free circulation of air* about the fruit. Accomplish this by avoiding low sites, by pruning and by removal of windbreaks. Spray as for leaf-curl and follow with two applications of potassium sulfide, 1 oz. to 3 gals., the first being made soon after the fruit is set and the second when the fruit is half grown. The self-cooked lime-sulfur wash has been shown to be very effective against this disease. See BROWN ROT. (Fig. 171.)

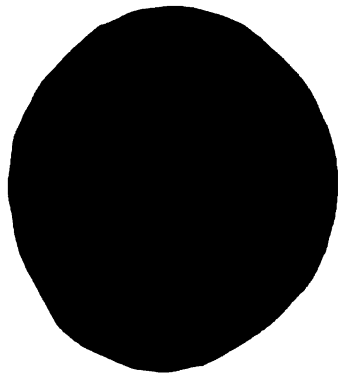


Fig. 171. *Black-spot on peach.*

Yellows is a so-called "physiological disease." Cause unknown. Contagious and quite serious in some localities. Known by the premature ripening of the fruit, by red streaks and spots in the fruit flesh and by the peculiar clusters of sickly, yellowish shoots that appear on the limbs here and there. Eradication is the only means of control. Dig out and burn diseased trees as soon as discovered.

PEAR.

Fire-blight. This is the same as fire blight of apple but it is more destructive to pears. It kills the twigs and branches on which the leaves suddenly blacken and die but do not fall. It also produces cankers on the trunk and large limbs. Prune out blighted branches as soon as discovered, cutting 6 to 8 inches below the lowest evidences of the disease. Clean out limb and body cankers as described for fire blight on apple trees. Disinfect all large wounds with corrosive sublimate solution, 1 to 1000, and cover with coat of paint. See Cornell Bulletin 236. *Avoid forcing a rapid, succulent growth of wood.* Plant the varieties least affected.

Scab is a fungous disease very similar to apple scab but it is not the same, however. It is very destructive to some varieties, as for example, Flemish Beauty and Seckel. Spray three times with Bordeaux as for apple scab. See Cornell Bulletin 145 and Geneva Bulletins 67 and 84. (Fig. 172.)

Fig. 172. *Pear-scab.*

PLUM.

Brown-rot is the same as brown rot of peach, and should be treated in the same way. (Fig. 173.)

Fig. 173. *Brown-rot on plum.*

Leaf-spot This is the same as leaf-spot of cherry and may be controlled by two or three applications of Bordeaux, 5-5-50. Make the first one about ten days after the blossoms fall and the others at intervals of about three weeks. This applies to European varieties. Japan plums should not be sprayed with Bordeax. See Geneva Bulletins 98 and 117.

Black-knot is the same disease as black knot of cherries and is controlled in same way. For control of this disease by spraying see Cornell Bulletin 81.

POTATO.

Blight and rot. There are different kinds of potato blight and rot. The most important are early blight and late blight—both fungous diseases. Early blight affects only the foliage. Late blight kills the foliage and often rots the tubers. Two serious troubles often mistaken for blight are: (1) Tip burn, the browning of the tips and margins of the leaves due to dry weather; and (2) flea-beetle injury, in which the leaves show numerous small holes and then dry up. The loss from blight and flea-beetles is enormous—often, one-fourth to one-half the crop. For blight, rot and flea-beetles spray with Bordeaux, 5-5-50. For addition of insect poisons see POTATO FLEA-BEETLES. Commence when the plants are 6 to 8 inches high and repeat every 10 to 14 days during the season, making 5 to 7 applications in all. Use from 40 to 100 gallons per acre at each application. Under conditions exceptionally favorable to blight it will pay to spray as often as once a week. See Geneva Bulletins 101, 123, 221, 241, 264, 267, 279 and 290.

Scab is caused by a fungus that attacks the surface of the tubers. It is carried over on diseased tubers and in the soil. In general, when land becomes badly infested with scab it is best to plant it with other crops for several years. See Vermont Bulletin 85 and Maine Bulletin 141.

QUINCE.

Leaf and Fruit Spot. This is a fungous disease producing round, reddish-brown spots on the leaves and fruit. Spray three times with Bordeaux as for apple and pear scab. See Cornell Bulletin 145. (Fig. 174.)

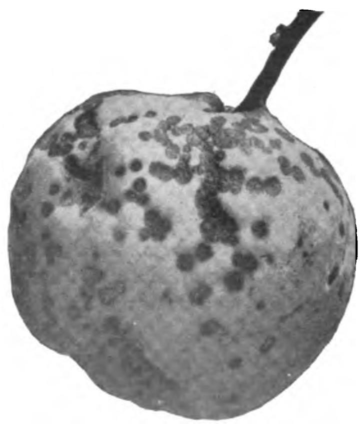


Fig. 174. *Fruit-spot on quince.*

RASPBERRY.

Anthracnose is very destructive to black raspberries but not often injurious to the red varieties. It is detected by the circular or elliptical, gray, scab-like spots on the canes. Avoid taking young plants from diseased plantations. Remove all old canes and badly diseased new ones as soon as the fruit is gathered. Although spraying with Bordeaux, 5-5-50, will control the malady, it may not be profitable. If spraying seems advisable make the first application when the new canes are 6 to 8 inches high and follow with two more at intervals of 10 to 14 days. See Geneva Bulletin 124. (Fig. 175.)

Cane-blight or wilt. This is a destructive disease affecting both red and black varieties. Fruiting canes suddenly wilt and die. It is caused by a fungus which attacks the cane at some point and kills the bark and wood thereby causing the parts above to die. No successful method of treatment is known. In making new settings use only plants from healthy plantations. Remove the fruiting canes as soon as the fruit is gathered. See Geneva Bulletin 226.

Red-rust is often serious on black varieties but does not affect red ones. It is the same as red rust of blackberry. Dig up and destroy affected plants.

Crown gall or root-knot. This is often destructive, particularly to the red varieties. It is detected by the large, irregular knots on the roots and at the crown underground. It is a contagious disease. *Never set plants showing root-knots.* Avoid planting on infested land. The same disease occurs on peaches.

Fig. 175. *Raspberry anthracnose.*

ROSE.

Black leaf spot is one of the commonest diseases of the rose. It causes the leaves to fall prematurely. Spray with Bordeaux, 5-5-50, beginning as soon as the first spots appear on the leaves. Two or three applications at intervals of ten days will very largely control the disease. Ammoniacal copper carbonate may be used on roses grown under glass. Apply once a week until disease is under control.

Mildew. For greenhouses roses, keep the steam pipes painted with a paste made of equal parts lime and sulfur mixed up with water. The mildew is a surface-feeding fungus and is killed by the fumes of the sulfur. Out-door roses that become infested with the mildew may be dusted with sulfur or sprayed with a solution of potassium sulfide, 1 oz. to 3 gallons water. Spray or dust with the sulfur two or three times at intervals of a week or ten days.

STRAWBERRY.

Leaf-spot is the most common and serious fungous disease of the strawberry. It is also called rust and leaf-blight. The leaves show spots which are, at first, of a deep purple color, but later enlarge

and the center becomes gray or nearly white. The fungus passes the winter in the old, diseased leaves that fall to the ground. In setting new plantations, remove all diseased leaves from the plants before they are taken to the field. Soon after growth begins, spray the newly set plants with Bordeaux 5-5-50. Make three or four additional sprayings during the season. The following spring, spray just before blossoming and again 10 to 14 days later. If the bed is to be fruited a second time, mow the plants and burn over the beds as soon as the fruit is gathered. Plant resistant varieties. See Cornell Bulletin 79.

TOMATO.

Septoria, leaf-spot is the most destructive foliage disease of the tomato in the state. The distinguishing character of this fungous disease is that it begins on the lower leaves and works towards the top, killing the foliage as it goes. It is controlled with difficulty because it is carried over winter in the diseased leaves and tops that fall to the ground. When setting out plants, pinch off all the lower leaves that touch the ground; also any leaves that show suspicious looking dead-spots. The trouble often starts in the seed-bed. Spray plants very thoroughly with Bordeaux, 5-5-50, beginning as soon as the plants are set out. Stake and tie up for greater convenience in spraying. Spray under side of the leaves. Spray every week or ten days.

TURNIP.

Club root is the same disease as the club root of cabbage. Same treatment.

Soft rot is a bacterial disease, the same as soft rot of cabbage. Plant on soils free from the disease. Avoid planting varieties especially susceptible to the trouble. The white turnip seems to be more susceptible than the yellow varieties.

WHEAT.

Stinking smut. This is usually not detected until harvest time. The affected heads appear nearly normal, only the kernels being attacked. The diseased kernels are composed of a brown, foul-smelling powder. They may be crushed easily between the thumb and finger. Readily controlled by treating the seeds with formalin solution as for oat-smut, which see. See U. S. Farmers' Bulletin 250.

Loose smut is conspicuous in the field at "heading" time. Both grain and chaff are attacked and transformed into a loose black powder most of which is blown away by harvest time leaving the stalk bare. It is common and destructive. In 1907, the average loss in New York was at least 10 per cent. This smut is not controlled by treatment with formalin or other chemicals, but should be prevented by treating the seeds with hot water as follows: Soak sack of wheat in cold water for 12 hours, drain 1 hour; submerge sack for ten minutes in water held at temperature of 130° F. The temperature must not rise above this as it would then injure the germinating ability of the grain.

V. FUNGICIDES.

H. H. WHETZEL AND C. S. WILSON.

The most important fungicides are as follows: Bordeaux mixture, ammoniacal copper carbonate, potassium sulfide, copper sulfate, flowers of sulfur, corrosive sublimate, formalin, lime-and-sulfur wash.

Bordeaux mixture.

Copper sulfate, 5 lbs.
Stone lime or quicklime (unslaked), 5 lbs.
Water, 50 gals.

Bordeaux is the most improtant fungicide for general use. The strength varies according to the plant to be sprayed. The formula given above is the strength usually recommended. When a different strength is necessary, the formula is given under that disease. Stock mixtures of copper sulfate and lime are desirable. They are prepared in the following manner:

Copper sulfate. Dissolve the required amount of copper sulfate in water in the proportion of one pound to one gallon several hours before the solution is needed, suspend the copper sulfate crystals in a sack near the top of the water. A solution of copper sulfate is heavier than water. As soon, then, as the crystals begin to dissolve the solution will sink, bringing water again in contact with the crystals. In this way, the crystals will dissolve much sooner than if placed in the bottom of the barrel of water. In case large quantities of stock solution are needed, two pounds of copper sulfate may be dissolved in one gallon of water.

Lime. Slake the required amount of lime in a tub or trough. Add the water slowly at first, so that the lime crumbles into a fine powder. If small quantities of lime are used, hot water is preferred. When completely slaked, or entirely powdered add more water. When the lime has slaked sufficiently, add water to bring it to a thick milk, or to a certain number of gallons. The amount required or each tank of spray mixture can be secured approximately from this stock mixture which should not be allowed to dry out.

To make Bordeaux. Take 5 gallons of stock solution of copper sulfate for every fifty gallons of Bordeaux required. Pour this into the tank. Add water until the tank is about two-thirds full. From the stock lime mixture take the required amount. Knowing the number of pounds of lime in the stock mixture and the volume of that mixture, one can take out approximately the number of pounds required. Dilute this a little by adding water, and strain into the tank. Stir the mixture, and add water to make the required amount. Experiment stations often recommend the diluting of both the copper sulfate solution and the lime mixture to one half the required amount before pouring together. This is not necessary, and is often impracticable for commercial work. It is preferable to dilute the copper sulfate solution. Never pour together the strong stock mixtures and dilute afterward. Bordeaux mixture of other strengths as recommended is made in the same way, except that the amounts of copper sulfate and lime are varied according to the requirements.

The ferro-cyanide test. It is not necessary to weigh the lime in making Bordeaux mixture for a simple test can be used to determine when enough of a stock lime mixture has been added. Dissolve an ounce of yellow prussiate of potash in a pint of water and label it

"poison." Cut a V-shaped slit in one side of the cork so that the liquid may be poured out in drops. Add the lime mixture to the diluted copper sulfate solution until the ferro-cyanide test solution *will not turn brown* when dropped from the bottle into the mixture. It is always best to add a considerable excess of lime.

BORDEAUX INJURY. (Fig. 176.)

Some plants are injured by the ordinary strength of Bordeaux even when properly made. Others, like the apple, are sometimes injured by quite a weak Bordeaux under certain weather conditions. The leaves of most varieties of stone fruits, especially peaches, and Japanese plums are most sure to be injured by Bordeaux except in very weak mixtures. The injury to these plants consists usually of small holes in the leaves, very similar in appearance to the shot-hole effect of certain fungi. The injury on apple occurs on both the leaves and the fruit. On the leaves it consists of quite definite brown spots very much like certain leaf spots due to fungi. The injury on the fruit takes the form of russeting. It may even cause large cracks to appear. Some varieties of apples suffer more than others. Wet weather during spraying season appears to be one of the chief factors in the production of Bordeaux injury on apples. It has also been shown that "the more copper sulfate, the greater the injury." It is to be understood, however, that injury from Bordeaux is much less common and serious than injury from the fungous disease, to prevent which it is applied. For a fuller discussion of this subject see Geneva Bulletin 287.

Fig. 176. *Bordeaux injury on apples.*

Ammoniacal copper carbonate. Copper carbonate, 5 oz.; ammonia, 3 pts.; water, 50 gals. Dilute the ammonia in seven or eight quarts of water. Make a paste of the copper carbonate with a little water. Add the paste to the diluted ammonia, and stir until dissolved. Add enough water to make fifty gallons. This mixture loses strength on standing, and therefore should be made as required. It is used in place of Bordeaux where one wishes to avoid the coloring of maturing fruits or ornamental plants. Probably, it is not as effective as Bordeaux.

If large amounts of the above mixture are required, it is more economical for the grower himself to make the copper carbonate. Proceed as follows: Dissolve 12 lbs. of copper sulfate (blue vitriol) in 12 gals. of water in a barrel. Dissolve 15 lbs. of sal soda in 15 gals. of water (preferably hot). Allow the solution to cool; then add the sal soda solution to the copper sulfate solution, pouring slowly in order to prevent the mixture from boiling up and running over. A fine precipitate which will settle to the bottom after the mixture has stood about twelve hours is formed. Siphon off the clear liquid above. Wash the precipitate by adding clear water, stirring and again allowing to settle. Siphon off the clear water, strain the precipitate through muslin, and allow it to dry. This is copper carbonate. The above amounts will make about six pounds.

Potassium sulfide. Potassium sulfide (liver of sulfur), 3 oz.; water, 10 gals. As this mixture loses strength on standing, it should be made just before using. It is particularly valuable for the powdery mildew of many plants, especially gooseberry, carnation rust, rose mildew, etc.

Copper sulfate. Copper sulfate, 1 lb.; water, 15-25 gals. Dissolve the copper sulfate in the water. It is then ready for use. One pound in twenty gallons of water has been found effective against peach leaf-curl. This mixture should never be applied to the foliage, but must be used before the buds break. A much weaker solution has been recommended for trees in leaf, but it is rarely used.

Sulfur. Sulfur has been found to possess considerable value as a fungicide. The flower of sulfur may be sprinkled over the plants, especially when they are wet. It is most effective in hot dry weather. In rose houses, it is mixed with half its bulk of lime, and made into a paste with water. This is painted on the steam pipes. The fumes destroy mildew on the roses. Mixed with lime, it has proved effective in the control of onion smut when drilled into the rows with the seed. Sulfur is not effective against black rot of grapes, and many other diseases.

Corrosive sublimate solution. Corrosive sublimate, 1 oz.; water, 7 gals. An effective solution for potato scab. Soak seed potatoes one and one-half hours. It is also a good antiseptic for dressing wounds. After cutting out fire blight or canker, swab the wound thoroughly with this solution.

Formalin. This is a gas dissolved in water. Commercially, it has a strength of about forty per cent. One pint dissolved in thirty gallons of water is used effectively in preventing potato scab (soak tubers for half an hour, and plant in clean soil), or smut of oats and stinking smut of wheat (soak seed in solution for ten minutes, drain and sow the next day).

Lime and sulfur wash. The lime-and-sulfur wash has considerable value as a fungicide. For its preparation and use, see under INSECTICIDES. A modified form of this wash, known as the "self-cooked" lime-sulfur wash, is now being recommended for the spraying of peaches, plums and apple foliage. It is said to cause no injury to the leaves or fruit. Good results have been secured in controlling brown rot and scab of peaches. Prepare as follows: Place ten pounds of sulfur and fifteen pounds of stone-lime in a barrel. Add hot water slowly to slake the lime, keeping the mass wet, but not submerged. Stir occasionally. Part of the large lumps of lime may be kept out at first and added after slaking has progressed to some extent, thus prolonging the slaking and heating. When slaked, dilute to fifty gallons, and apply as you would Bordeaux.

"Sticker" or adhesive. Resin, 2 lbs.; sal soda, (crystals) 1 lb.; water, 1 gal. Boil until of a clear brown color — one to one and one-half hours. Cook in iron kettle in the open. Useful for onions, cabbage and other plants hard to wet. Add this amount to each fifty gallons of Bordeaux. For other plants, add this amount to every one hundred gallons of the mixture. This mixture will prevent the Bordeaux from being washed off by the heaviest rains.

APRIL, 1908 BULLETIN 253

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Plant Pathology and Horticulture

THE BLACK-ROT OF THE GRAPE, AND ITS CONTROL

BY
DONALD REDDICK AND C. S. WILSON

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The regular bulletins of the Station are sent free to persons residing in New York State who request them.

I. THE FUNGUS THAT CAUSES BLACK-ROT OF GRAPES.

BY DONALD REDDICK.

While black-rot has been present in New York for a long time, during the past few years losses from this source have been increasing. In the period from 1904 to 1906 they were very heavy, amounting to an entire failure in many localities. Recognizing the serious nature of the trouble and giving heed to the earnest request of certain large growers, a thorough investigation of the nature of this disease has been instituted at this Station. These pages are in the nature of a preliminary report on the progress of the work. The facts here recorded have been observed during the past year, at the special field station located at Romulus, N. Y., and have been confirmed by observations in other localities. No claim is made to originality for indeed most of the observations recorded here have been published at some time by various investigators in other State Experiment Stations, notably by Scribner and later Galloway, U. S. Department of Agriculture; Chester in Delaware; Price in Texas; Selby in Ohio; and others.

It is a function of all plants to reproduce themselves and thus perpetuate and propagate the species. This function is performed by the plants with which we are best acquainted, by means of seeds. The seed is a resting stage and serves to carry the plant through the winter.

There are, however, a very large number of plants known to the casual observer only by the effect they produce. This is because of their small size and the necessity of a microscope to examine and study them. They, however, are similar to other plants in that they produce a winter or resting stage, the unit of which is called a *spore*. Among this large number of microscopic plants is a group known as fungi. It is to this group (many of them parasites), that we may attribute a large number of the diseases of cultivated plants as well as some of those of animals.

Nature of black-rot.

The black-rot of grapes is caused by a fungus which lives as a parasite on the green parts of the vine and fruit, thus sapping the vitality of the vine and often destroying all the fruit. This fungus (*Guignardia*

bidwellii) produces its winter or resting stage on the black hard mummied grape berry or its pedicel (Fig. 177). Its spores are contained in tubular sacs, each sac or *ascus* containing 8 spores. A large number of the sacs (20-50) are grouped close together and surrounded by several layers of thick-walled cells. Protection is thus assured for the spores or germs. This cluster of sacs with their thick protection appears to the naked eye as a very small pimple on the surface of the mummied berry. Every berry may have a hundred or more such pimples, which are technically known as *perithecia*. (See Fig. 178.)

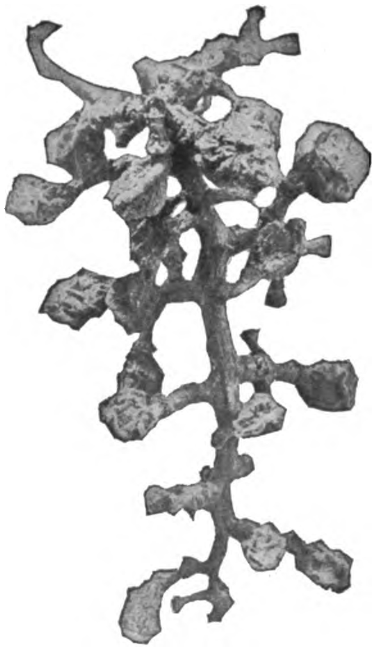


FIG. 177—*The mummy berries, on which the fungus passes the winter.*

Some of the spores are ripe and ready to grow about the time the first three or four leaves on the new shoots appear. Others do not ripen until later. If the first fail to start the disease, those produced later will.

This succession of maturity of spores is such that as late as October winter-spores just in condition to grow can be found. This at least was true during the past season, which was very dry. The fungus, just as any field crop, must have moisture in order to grow.

The accompanying illustration (Fig. 178) is of a thin section through the middle of the perithecium, taken at a stage when only a few of the sacs have mature spores. In the others, the spores are not yet formed. The section is greatly magnified and shows the condition when water is added. In the vineyard, this would mean whenever rain or dew lodged on the mummied berry. The sacs that contain ripe spores become gelatinous and, being swelled by the addition of water, protrude themselves beyond the wall of the perithecium. For this reason, poisonous substances sprayed on the mummies are not effective, since they do not touch the germs.

Distribution of the germs.

Now a most interesting thing, as seen under the microscope, takes place. The spores are crowded to the upper end of the ascus and the one at the tip can be seen to be moving. It is as though the spore

which is widest at the middle, were trying to squeeze through a tight place. At first, it moves slowly, but eventually the widest part passes the constriction and the spore is snapped into the air. It is often thus discharged for a distance of more than a centimetre (½ inch). The next spore is pushed up and follows closely after the first, so that all eight spores may be discharged into the air in the course of ten minutes.

Critical stage.

Now comes the most critical stage for the fungus. In order to continue its existence the spore must fall upon some green part of the vine, either stem, tendril, leaf, or young cluster. The only plant, other than the grape, on which it is known to grow is the Virginia creeper or 5-leaved ivy. It will not grow on weeds, grass, posts, wires, or on any dead material except by careful nursing in the laboratory. If the cluster of mummies is clinging to the vine, it is easy for the spores to fall down and lodge on a leaf or even be blown across to other vines. Most of the mummied berries, however, are knocked off in pruning and are lying on the ground. The fungus is therefore largely dependent on the wind to blow the spores to the leaves or fruits, and for this reason a comparatively small number ever survive.

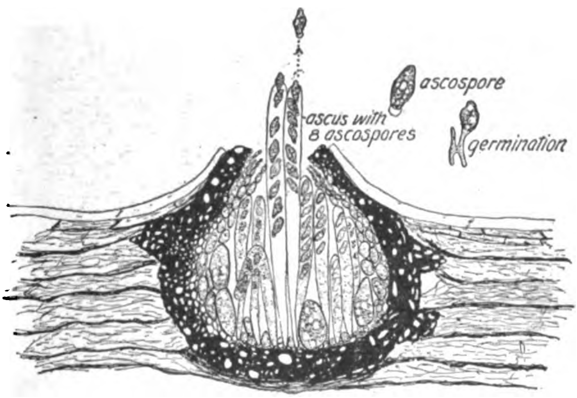


FIG. 178—*Diagrammatic section of a perithecium containing winter-spores. The spores do not all mature at the same time. Germination of the spores can be seen at the right. (Greatly magnified.)*

Infection.

The spore that lodges upon a green part of the vine must have a drop of water, though it may be very small, in which to germinate and grow. Germination rarely takes place in less than 36 hours. In 36 to 48 hours a small bud or protrusion (germ tube) appears on one side, see (Fig. 178), and as it grows the tip makes its way through the surface of the leaf or

green stem. Growth of the tube continues by the absorption of sap and other food material from the vine. The fine thread-like tube branches and spreads out for a short distance on the inside. Cross-walls are now formed and the growth is known as ***mycelium***. The mycelium is the vegetative or growing stage of the fungus and, although rarely seen, is the stage which does the great damage. The threads not only push between the cells of the grape and in that way absorb the sap which would normally flow from one cell to another, but also penetrate directly into the cell and take up food material there. When the mycelium has established itself on the inside and can no longer be prevented from grow-

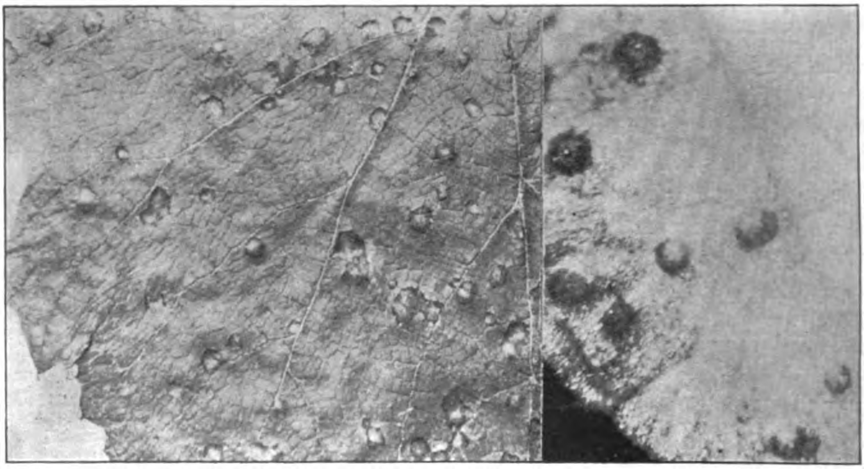


FIG. 179—*On the left, black-rot spots on the leaf (natural size); on the right, photomicrograph of a small portion of a single spot showing fruit bodies of the fungus.*

ing or be killed by means of a poisonous spray, ***infection*** is said to have taken place; the leaf or vine is infected.

Incubation.

The mycelial threads grow for a short distance in all directions from the point of infection; never as much as an inch and usually not more than ⅛ to ¼ inch. This growth takes place rather slowly and there is no external evidence of it until 12 to 20 days after infection took place. This time is known as the *period of incubation*. At the end of this time the diseased area changes color and that part of the leaf becomes yellowish brown in color. (See Fig. 179).

Pycnidia.

The mycelium serves the treble purpose to the fungus of root, stem and leaf. It alone develops a receptacle in which reproductive bodies are produced, while the root, stem and leaf of the stalk of corn all contribute to the production of an ear (seed). The fruiting bodies of the fungus that contain the summer spores (Fig. 180) are formed of very short interwoven branches of the mycelium which become thick-walled and black, and are known as *pycnidia*. There is a small circular opening at the top. The pycnidia form a more or less concentric ring on the spot and there are from 5 to 30 or more of them on a single spot, visible to the naked eye as very small pimples. The interior of each pycnidium is lined with a layer of delicate club-shaped bodies. These are specialized mycelial threads, and the summer-spores or *pycnospores* are formed on their tips. Summer-spores are formed in this way until the pycnidia become filled with them.

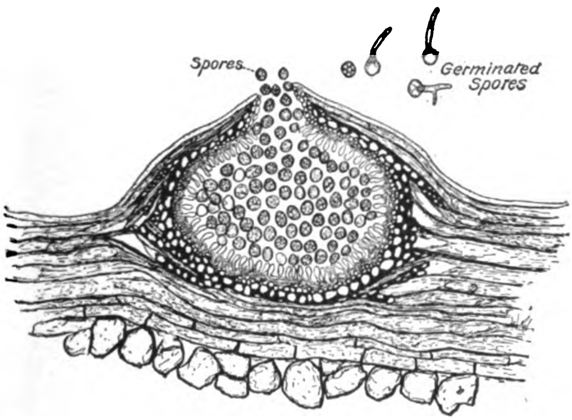


FIG. 180—*Diagrammatic section through a single pycnidium, showing how the summer-spores are produced and how they germinate.* (*Greatly magnified.*)

Summer-spores.

These spores are surrounded by a gelatinous substance. When a drop of water is placed on a ripe pycnidium, this gelatinous substance swells and the pycnospores are forced out through the hole in the top in a fine white thread-like stream. (Fig. 180). The pycnospores germinate in water in 18 to 24 hours, grow, form a new mycelium and produce exactly the same effect as the winter-spores. They also have the particular advantage of being on the leaves or stems and later on the berries from which the wind may carry them for considerable distance to other vines.

Stages of infection.

In Fig. 181 are shown the spots formed by the first infection of 1907 on stem, leaf, leaf petiole and tendril. These spots are frequently overlooked by the grower. To many, the first signs of the black-rot is the blackening of the pedicel of the berry. This, however, is only one of the many points of first infection. The little berry is protected by the calyx

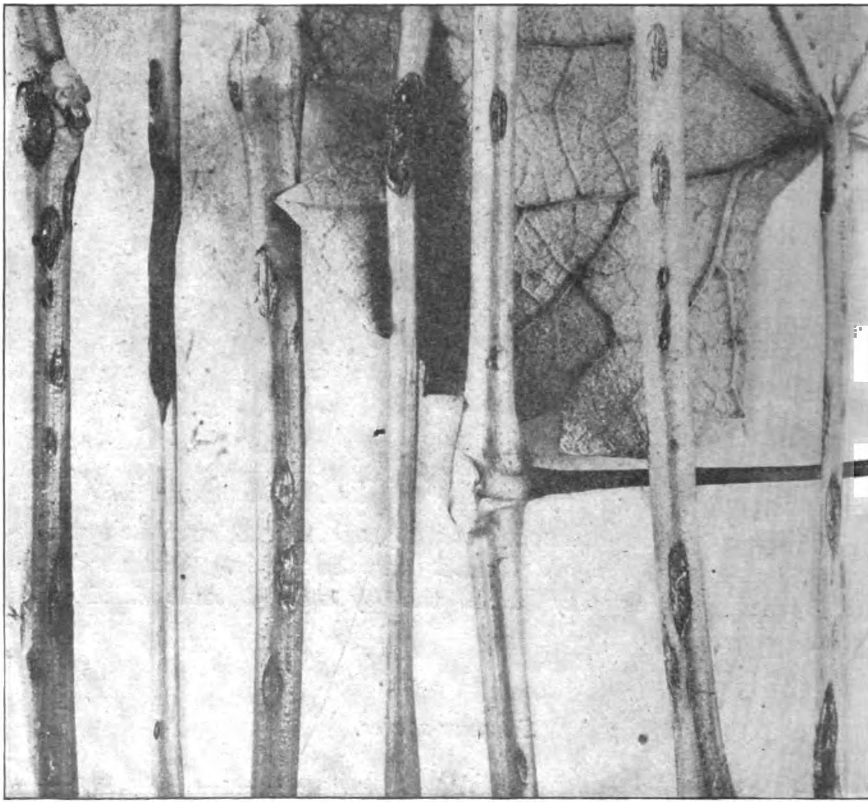


FIG. 181—*Black-rot fungus on the canes, showing as pits and blotches.*

which falls off at blooming time while its pedicel is not so protected; but as the source of sap is cut off the berry fails to develop.

In the vineyards at Romulus in 1907, the first infection from winter-spores took place with the rain of June 22nd and 23rd, which was followed by showers and cloudy weather. The first spots appeared July 10th. The period of incubation was thus from 16 to 18 days. The second

infection from winter-spores took place June 30th and the 48 or 60 hours of cloudy and rainy weather following. The spots appeared July 17th and later. The vines were in full bloom June 28th and no doubt some of the small berries were infected at this time, though the number was comparatively small. The third infection took place from ascospores also, for no pycnospores were mature at this time, and proved to be more abundant on berries than any place else. The ascospore, if it has the moisture, will penetrate the berry just as it did the leaf. The infection came with the gentle rains of the 11th and 12th of July, and the first external indications appeared on July 21st and 22nd.

Period of incubation.

The period of incubation in the juicy berry is usually from 8 to 14 days at the end of which time a small circular, whitish spot 1 to 2 mm

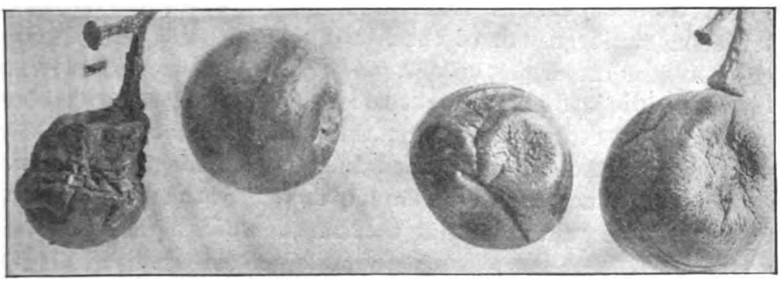


FIG. 182—*Showing stages in the rotting of the fruit.*

(1-12 in.) in diameter, appears. This enlarges rapidly and in 48 to 60 hours may involve half of the berry. About this time a blackening appears at the center of the spot. This is caused by the formation on the mycelium and just under the cuticle of the berry of a large number of pycnidia. These form very rapidly and in 24 hours more than half of the berry may have turned black. Thus it is that one frequently hears it said, "the whole vineyard rotted down in a day."

Black-rot on the berry.

It occasionally happens that the effect on the berry is much like that on the stem, so that a black crust is formed only on one side of the berry. Usually, however, the whole berry is involved. By the time the whole berry has become discolored, wrinkles are appearing on the side first attacked and eventually the berry becomes wrinkled and black and dry. (Fig. 182). The pycnidia are very numerous on these mummified berries

and they contain great quantities of pycnospores which with another rain and favorable weather produce another infection. And so it is that during the entire season following every rain there is a new infection which becomes evident on the berries about ten days or two weeks later. If the conditions are right, the berry will be infected at any stage up to the time it is ripe and ready to pick. The rot does not go from one berry to another except by means of spores.

The effect of dry weather.

The remainder of the month of July, 1907, after the 12th, and most of August was very dry. Very few infections took place during this period. There was an enormous number of pycnospores formed in the pycnidia on the rotted berries and on other parts of the vine but for want of moisture these remained in the pycnidia, protruding slightly and forming a white speck at the apex.

With the rapid growth of the healthy berries the opening in the cluster, caused by the drying up of some berries from black rot, soon fills. In some cases, it is just as well that some of the berries be removed but in the case of a light setting, every berry that rots represents an actual loss, to say nothing of the danger of spreading the disease to other berries. It very frequently happens that as much as 25% of the crop may disappear in this way without attracting the attention of the grower.

Preparation for winter.

When the pycnospores are discharged from the pycnidia, the latter become entirely filled with whitish cells and remain through the winter in this way. In the spring these cells elongate to form the ascus, and the whitish content breaks up to form the eight spores.

Other sources of infection.

It frequently happens that pycnospores formed on the berries in the autumn have thicker walls and are not discharged from the pycnidia. They lie thus through the winter and the following spring are discharged and produce an infection. It also happens that the pycnospores are not discharged from some of the pycnidia on the tendrils or stems. These live and are capable of producing an infection.

With the above facts in regard to the life-history of this fungus, the reasons for the recommendations at the end of this bulletin will become apparent. Further information in regard to any of these points will be gladly furnished by addressing an inquiry to the Department of Plant Pathology, New York State College of Agriculture, Ithaca, N. Y.

II. THE CONTROL OF BLACK-ROT.

Under the direction of Professor JOHN CRAIG.

BY C. S. WILSON.

EXPERIMENTS OF 1906.

Three experiments were conducted by the Department of Horticulture under the direction of Professor Craig. The purpose of these experiments was to study the effectiveness of different fungicides for controlling the black-rot. They were conducted in the vineyards of the Niagara Grape Company at Romulus, N. Y., which are under the superintendency of Mr. G. G. Lansing; in the vineyards of Mr. H. H. Bradley King Ferry; and Mr. M. E. Sperry, Ludlowville.

The vineyard of the Niagara Grape Company is situated about two miles from the west side of Cayuga Lake. The land slopes slightly to the east. The soil is a rich clay loam, and for several years the vineyard has been well cultivated. The vines are about twenty years old, and had been well sprayed previously. In 1905, black-rot destroyed the entire crop. The variety is Niagara.

Mr. Bradley's vineyard is situated on the east side of the lake at King Ferry. The land slopes sharply to the west. The soil is a sandy or gravelly loam, and has been well cultivated. The vines are nineteen years old. Since the black-rot has not yet seriously affected the vineyard, it has been sprayed for two or three years only. In 1905, portions only and not the whole vineyard were affected. In the experimental plat the variety is Catawba.

Mr. Sperry's vineyard is on the east side of the lake at Ludlowville. The land slopes sharply to the west. The soil is a gravelly loam. For the last four years the vineyard has been poorly cared for, and the vines have not been sprayed. In 1905, the black-rot destroyed nearly the entire crop. The variety is Concord.

No accurate results were obtained from Mr. Sperry's vineyard. The grapes rotted badly, burst open early, and were picked before the yields were computed. The results as shown by field notes substantiate in a general way the findings secured in the other two vineyards.

A plat or block was chosen in each vineyard, all parts of which plat were under nearly uniform conditions. Thirteen rows, each twenty to twenty-five rods long, were selected and treated as follows:

1. Check (unsprayed).
2. Bordeaux, 5–4–40 + sulphur 6 lbs. to 40 gals.
3. " " " 4 " " "
4. " " " 2 " " "

5. Check.
6. Bordeaux, 5–4–40, (two applications). Ammoniacal copper carbonate (three applications).
7. Bordeaux (five applications).
8. " (four ").
9. " (three ").
10. Check.
11. Bordeaux, 6–4–40.
12. " 4–4–40.
13. Check.

Each plat was sprayed five times as follows:

Niagara Grape Company	H. H. Bradley
1st. April 21st to 27th.	May 12th.
2nd. May 24th.	June 22nd.
3rd. June 6th.	July 10th.
4th. July 11th.	Aug. 7th.
5th. Aug. 20th.	Aug. 17th.

Probably the vines were more thoroughly sprayed than they would be by the commercial vineyardist, yet not more thoroughly than would be practicable for him.

The appearance of the disease was first noticed in the vineyard of the Niagara Grape Company on June 23rd, at which time it was prevalent in the form of small round spots on the leaves. No trace of it was as yet visible on the berries. On June 30th, it was found on the berries, which at that time varied in size from that of a radish seed to a small pea. On July 1st, probably five per cent of the clusters on each vine showed a little rot. The diseased berries were not confined to the tip, but appeared on any part of the bunch.

From this time, the disease spread very rapidly, and on July 17th a very general outbreak which practically ruined the entire crop appeared. Probably, there was not one bunch in a thousand that was not affected. After July 17th, the rot spread very little, and very slowly. This condition continued until the fruit ripened. In the vineyard of Mr. Bradley, it appeared at a later date, and was less violent.

Two methods were employed to compute the results, one based on the number of the clusters, the other on the weight of the fruit. As time would not permit the Experiment Station men to pick the fruit from the entire plat, cross sections were selected in which conditions were as uniform as possible. In the vineyard of the Niagara Grape Company two sections were chosen; in the vineyard of Mr. Bradley, three. The entire crop was picked from these sections, and the clusters sorted into

grades, usable and nonusable. These grades were arbitrarily chosen. Under the head of usable, were classed those bunches of which the majority of berries were sound. Some bunches were nearly perfect; others contained a few rotted berries. One could scarcely call the fruit of this grade marketable.

As non-usable, were classed the remaining clusters of which the majority of berries had rotted. The number of usable and non-usable clusters was counted in every case. Each grade was also weighed.

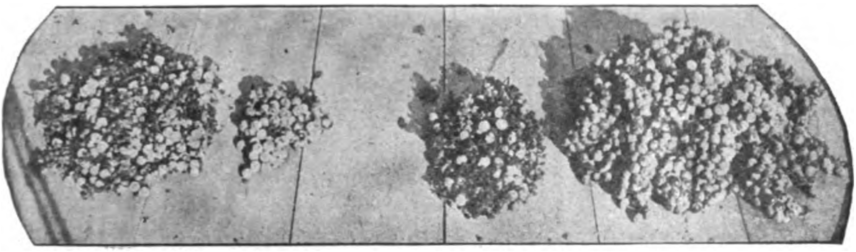


FIG. 184—*Fruit from sprayed and check rows.*

From left to right:
1. Non-marketable fruit from check row.
2. Marketable fruit from check row.
3. Non-marketable fruit from sprayed row.
4. Marketable fruit from sprayed row.

In the case of the Niagara Grape Company, the fruit that remained on the vines after the Experiment Station men had computed their results was picked by Mr. Lansing himself. This was taken to the packing house and graded by the packers. A record was made of the number of pounds picked from each row.

The results in tabular form are given below:

	No. lbs. of fruit packed for market	Niagara Grape Co.				H. H. Bradley's.			
		Clusters		Weight		Clusters		Weight	
		Usable %	Non-Usable %	Usable %	Non-Usable %	Usable %	Non-Usable %	Usable %	Non-Usable %
1. Check	6½	27	73	55	45	24	76	47	53
2. Bor.-sulphur 6 lbs.	81½	59	41	81	19	73	27	87	13
3. " " 4 "	103½	68	32	88	12	82	18	90	10
4. " " 2 "	118½	78	22	92	8	84	16	92	8
5. Check	½	18	83	40	60	40	60	66	34
6. Bor. 2 ap. A. C. C. 3 ap.	99	79	21	87	13	70	30	84	16
7. " 5 applications	61	70	30	84	16	86	14	93	7
8. " 4 "	84	62	38	84	16	81	19	93	7
9. " 3 "	65	65	35	79	21	77	23	87	13
10. Check		3	97	12	88	43	57	67	33
11. Bor. 6-4-40	46	62	38	86	14	81	19	92	8
12. " 4-4-40	36	34	66	60	40	87	13	94	6
13. Check	½	20	80	31	69	50	50	64	36

Deductions from the experiments of 1906

1. Unsprayed rows yielded no marketable fruit.
2. No striking differences were shown by the different sprays.
3. The addition of sulphur did not increase the efficiency of the spray to a noticeable degree.
4. The best results were secured with Bordeaux, 5–4–40, + sulphur 2 lbs. to 40 gals.
5. Spraying after the rot appeared apparently did not affect its spread.
6. The foliage was much healthier and freer from disease on the sprayed rows.
7. The rot was worse on fruit in the immediate vicinity of dried clusters of previous years. This emphasizes the necessity of removing all dried clusters or other means by which the disease may be carried over winter.
8. A normal yield for one row in the vineyard of the Niagara Grape Company approximated 400 pounds. The largest yield from any sprayed row in the same vineyard amounted to 132 pounds. This represented a loss of sixty-seven per cent caused by the rot, or a saving of thirty-three per cent caused by the spraying. While this is unsatisfactory from the standpoint of effective protection, yet the thirty-three per cent. saved much more than paid for the operation. It is a question, however, if grape-growing could be conducted with profit on this basis, counting expenses and interest on investment.

On the other hand, in the vineyard of Mr. H. H. Bradley, fully eighty per cent of the crop was saved, the loss amounting to about twenty per cent only. Spraying, therefore, with Mr. Bradley proved of great commercial value.

EXPERIMENTS OF 1907.

The work of 1906 showed marked results in favor of spraying. The experimenters, however, did not feel that the problem was solved for the commercial grower. Work on a larger scale must be done, and the results computed from the standpoint of the grower. Such work was undertaken in the year 1907. A plat of ten acres was chosen in the vineyard of the Niagara Grape Company. The experiment was planned and conducted with the greatest care consistent with the scale on which the work was carried out. If the rot could be controlled by spraying, the experimenters were determined to control it. The map shows the general plan of the work.

ROW NUMBER		PLAT NUMBER
1		
2-6	Bordeaux, 5-5-50; resin sal-soda sticker	1
7-11	Bordeaux, 5-5-50; resin fish-oil soap sticker	1
12		
13-17	Sprayed and treated as Mr. Lansing treated vineyard	2
18-22	in 1906. (See following paragraph)	2
23		
24-28	Bordeaux, 5-5-50; clusters bagged	3
29-33	Bordeaux, 5-5-50; clusters not bagged	3
34		
35-39	Bordeaux, 5-5-50; clingers burned	4
40-44	Bordeaux, 5-5-50; clingers not burned	4
45		
46-50	Bordeaux, 6-6-50.	5
51-55	Bordeaux, 6-6-50.	5
56		
57-61	Bordeaux, 5-5-50.	6
62-66	Bordeaux, 5-5-50.	6
67		
68-72	Bordeaux, 4-4-50.	7
73-77	Bordeaux, 4-4-50.	7
78		
79-83	Check	8
84-88	Iron sulfate, 5-5-50.	8
89		
90-94	1st application, lime and sulfur; others, Bordeaux	9
95-99	1st application, copper sulfate solution; others, Bordeaux	9
100		

The plat consisted of 100 rows, 53 vines per row, vines 10 feet apart, rows 9 feet. The area was divided into nine different plats, with one check row between each plat. Each plat was again divided into two parts. The purpose of such division was to test a few of the less important treatments in view of suggestions for future work, and also to make the tests comprehensive. The map, therefore, is made with such divisions, and the results are tabulated accordingly. The treatment of Plat 2 (sprayed and treated exactly as Mr. Lansing did last year) is as follows:

FIG. 184—*A good grape hoe.*

The soil is plowed from the rows in the spring, and the rows worked with the grape hoe. No further treatment is given until July, when the soil is plowed back to the row, and left until the following spring. The vines are sprayed three times: First, before the buds swell; second, before the blossoms open, third, after the blossoms fall. At each spraying two small Vermorel nozzles were used on each side of the machine, one nozzle for each wire. Plat 1 received the same cultivation as Plat 2.

The rest of the plats were sprayed as follows:

First, May 3-9.
Second, June 7-8.
Third, June 26-27.
Fourth, July 9-10.
(Note: Rows 35-44 also sprayed July 16).

Fifth, July 23-24.

Sixth, Aug. 5-6 (Ammoniacal copper carbonate on all plats except check and No. 2).

Seventh, Aug. 20-21 (Ammoniacal copper carbonate same as above).

Cultivation.—Plats 3, 4, 5, 6, 7, 8, 9 were plowed in the spring. The soil was thrown from the rows. The grape hoe was used to cultivate between the vines, and following this for clean work, the hand hoe. The furrows were then cut with a cutaway harrow. The spring-tooth harrow followed this, leaving the ground level and mellow. Cultivation was

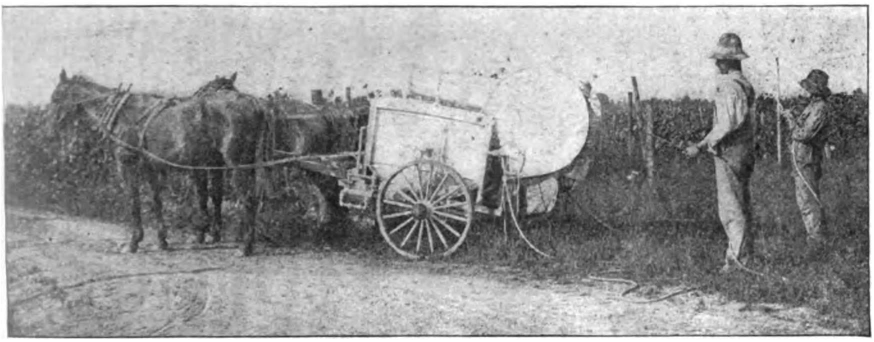


FIG. 185—*Vineyard sprayer used in the experiment, showing stationary nozzles at side: also trailers with extension rod.*

continued on these plats until about the middle of July when cover-crops were sown as follows:

Rows	24–28 crimson clover	July	16
"	29–33, vetch	"	16
"	35–39, crimson clover	"	16
"	40–44, vetch	"	16
"	46–50, mammoth clover	"	24
"	57–61, crimson clover	"	24
"	90–99, buckwheat	"	24

The latter part of the summer was dry, and the cover-crops did not grow well. Vetch and buckwheat did the best, with crimson clover third.

The appearance of the rot.

On the night of Thursday, July 10, the rot was first discovered on the leaves. It was almost entirely on the suckers at the base of the vines,

and appeared as small spots mostly on the upper surface of the leaf. On Monday night, July 15, the first rot was found on the berries. This appeared to be a small epidemic. More rot showed Tuesday morning. On sprayed rows, it was necessary to hunt to find a rotted berry. On unsprayed rows the rot was more evident. For about a week, the berries continued to rot slightly. On July 22, another slight epidemic began when a number of the berries rotted. One could find a handful in walking along a row. Following this was a period of dry weather during

FIG. 186—*A cover-crop of buckwheat.*

which very little rot appeared. Another small epidemic seemed to sweep over the vineyard about the 20th of September.

The grapes were picked October 10-17. All the fruit was picked from each plat and weighed, giving total weight. Grapes were then run through the packing house and graded, the weight of the commercial grade, and the weight of the culls being obtained. From these weights the percentages were computed. They are given in the following table:

TREATMENT	Total weight grapes	Weight commercial grade	Weight culls	Per cent commercial
PLAT	lbs.	lbs.	lbs.	%
1 Bordeaux, 5–5–50; resin sal-soda sticker.	2541	2116	425	83
" 5–5–50; fish-oil soap sticker..	1938	1566	372	76
2 Same as Mr. Lansing's treatment in 1906.	2494	2070	424	83
Same as Mr. Lansing's treatment in 1906.	2494	2070	424	83
3 Bordeaux, 5–5–50; clusters bagged......	2298	2186	112	95
" 5–5–50; clusters not bagged..	2318	1620	698	70
4 " 5–5–50; clingers burned......	2403	2238	165	93
" 5–5–50; clingers not burned..	2306	2034	272	88
5 " 6–6–50	2543	2218	325	87
" 6–6–50.....................	2133	2028	105	95
6 " 5–5–50.....................	2988	2848	140	94
" 5–5–50.....................	2275	2111	164	93
7 " 4–4–50.....................	2853	2660	193	93
" 4–4–50.....................	2854	2660	194	93
8 Check..............................	2217	1554	663	70
Iron sulfate, 5–5–50..................	2181	1713	470	78
9 First application, lime and sulphur; others Bordeaux.........................	2416	2304	112	95
First application, Cu SO_4, solution; others Bordeaux.........................	2540	2010	530	79
10 10 Check rows=1 Plat.................	4360	2890	1471	66

COST AND RETURNS.

The yield of commercial grapes per acre from an average of four acres well sprayed..	4770 lbs.
Check..	3108 "
Gain..	1662 lbs.
at 2½ cents per pound.............................	$41.55
Cost of material and labor for spraying...........................	8.60
Saved per acre......................................	$32.95

The season of 1907 was comparatively dry, and not favorable to the development of the disease. In spite of this fact, good results were obtained which show that, when the rot is prevalent to a moderate degree, spraying will completely control it. We see from this table that all sprayed rows had very little rot, whereas the loss in the case of the check rows was 34 per cent and in the case of the check plat 30 per cent to say nothing of the extra labor of handling the poorer grades. Plats 4, 5, 6,

and 7, which were well sprayed and cultivated, averaged only 8 per cent. loss.

Iron sulfate mixture gave a loss of 22 per cent or a saving of 8 per cent over the check plat. One could detect very little difference between the plat sprayed with iron sulfate and the check plat. This mixture appears to be ineffective—in fact, little better than nothing—in controlling the rot.

The results obtained by burning the clingers are quite marked. It is a question, however, whether it pays on a commercial scale. The work was done with a large torch, made by the Pearsall Manufacturing Co., Texas. The principle of the torch is the same as that of a plumber's torch, except larger. It required one gallon of gasoline to burn the clingers from one row of fifty-three vines, and working only on one side of the trellis. Undoubtedly most spores were destroyed, but a few escaped. More satisfactory work could be done by using an ordinary plumber's torch and burning on both sides of the trellis. The burning of clingers is not recommended for commercial work.

The effect of spraying and cultivation on the health of the vine and maturity of the fruit was very marked. At the time of picking, the foliage on the experimental plat was green and healthy. Very little had fallen from the vines, whereas the foliage on other parts of the vineyard which were not well cultivated nor as thoroughly sprayed had mostly fallen. The few that remained were yellow and ripe. Practically, it is desirable to have an abundance of foliage in the fall. In case of frost, the foliage acts as a protection.

The fruit on the experimental plat ripened the earliest of any on the whole vineyard of 150 acres. They were sweeter than elsewhere, and could be picked first. As to the cause of this, the writer will not attempt to make a positive statement. It is his opinion, however, that it was the result of cultivation more than spraying.

The result of work at Penn Yan.

A demonstration experiment to control the black rot was carried on in the summer of 1907 in the Keuka Lake region. The work was done in the vineyard of Mr. S. C. Williams. Four rows in solid block and each forty rods longs, were sprayed with Bordeaux, 5–5–50. Two adjoining rows in solid block were left unsprayed as checks. The plat was sprayed as follows:

May 10th, June 9th, June 28th, July 13th, (Bordeaux, 5-5-50), Aug. 7th, (Ammoniacal copper carbonate, 5–3–50.)

The rot was first discovered on the leaves June 28th. The spots were about one-eighth of an inch in diameter, and clearly defined, though

not numerous. The disease was first seen on the berries about July 10th. On July 13th, all the berries were picked from a sprayed and unsprayed vine and counted. Seventeen per cent had rotted on the sprayed vines, and twenty-seven per cent on the unsprayed. A slight epidemic appeared to have swept over the vineyard about this time. Following this, there was a period of dry weather and very little rot appeared. No other epidemic appeared during the season.

FIG. 187—*The bagging of grapes.*

The grapes were picked October 21st and 22d. A heavy frost occurred on the morning of October 21st. This did not interfere with picking or grading of the grapes. Records were made of the net yield as picked. The fruit was then taken to the packing house and graded. The weights of the commercial grade and the culls were then computed. The green grapes were placed in a grade by themselves. The results obtained were as follows:

	Total weight grapes lbs.	Weight commercial grade lbs.	Weight culls lbs.	Per cent commercial
Sprayed rows	1322	1291½	30½	97
Unsprayed rows	606	564½	41½	93

There were four rows of sprayed grapes, and two rows of unsprayed,

Of the 1291½ pounds of grapes from sprayed rows, there were 158 pounds that were sorted out and graded as green grapes. Mr. Williams stated that these would sell at ten dollars a ton. In a non-experimental plat these green grapes would have been left to ripen, and would probably have come in with the number one of commercial grade, There was a much smaller quantity of green grapes in the unsprayed lot, 41 pounds only in the total of 564½ pounds,

Bagging.

Growers think that enclosing the bunch in a sack soon after the fruit forms has several advantages:

(a) Protection from mechanical injury.
(b) Protection from frost.
(c) Delays maturity or ripening.
(d) Protection from rot.

The writer does not wish to discuss the first three. Plat 3 was planned in order to determine what protection from the rot a bag afforded the bunch. The results are marked. A portion of the plat was bagged immediately after the blossoms fell and before the appearance of the rot. The remainder was bagged about ten days later, which is as early as is practicable on a commercial scale. The results were determined by computing the per cent of bunches free from rot. Several hundred bunches were counted, and computations made in different parts of the plat. The results were in favor of the unbagged bunches. In the vineyard at Romulus (Niagara), an average of the different computations showed sixty-two per cent of the bagged bunches free from rot, and thirty-eight to contain rotten berries. Of the unbagged, seventy-six per cent were free from rot, and twenty-four contained rotten berries.

The vineyard at Penn Yan showed the same results, although fewer bunches were treated. Twelve clusters were bagged on the unsprayed rows, and every cluster carried from three to thirteen rotten berries. Forty clusters were bagged on the sprayed row, thirty-one of which were more or less rotted, and nine absolutely free from rot. By weight there were nine and one-half pounds of the bagged grapes. Of these two pounds were absolutely free from rot, while seven and one-half pounds carried a considerable number of rotten berries.

III. RECOMMENDATIONS FOR CONTROL OF BLACK-ROT

The most vulnerable point of attack is against the old mummies. If it is practicable, these should be gathered at picking time along with the gleaning, and after the separation in the packing house the whole rotted mass burned. In this way, great quantities of rot are removed and sources of infection for the next year destroyed.

In the spring, plow just as deeply as possible without disturbing the roots too seriously. Turn the ground completely over, thus burying the rotted berries three to six inches under the surface. Plow as near the vines as possible with a two-horse plow, and then use a one-horse plow to get nearer. Use a horse-hoe to turn the remaining debris and soil from under the rows into the furrow. Some mummies will remain on the surface even after such treatment, but each cultivation will cover up a few of these or at least disturb them and reduce their chances for maturing spores. Keep all weeds and grass down.

After trimming, there will be a few mummies left on the arms. The trimmers should be instructed to gather these and as opportunity affords burn them. All brush should be burned clean.

Never allow basal water-sprouts to spread out over the ground; they are prime centers of infection. Keep the vines off the ground.

A cover-crop of crimson clover, vetch or buckwheat, planted about the middle of July or earlier, is desirable.

Spray thoroughly: first, with Bordeaux mixture, 5–5–50, at the time when third or fourth leaf is showing; second, with the same mixture just when blossoms are swelling; third, with the same mixture soon after flowers have fallen.

The remaining applications will depend upon the weather. If the season is rainy, the applications should be made at intervals of ten days to two weeks; if dry, fewer applications will be necessary. Until July 20th use Bordeaux, 5–5–50; after this time use ammoniacal copper carbonate, 5–3–50. The latter solution will not discolor the grapes as Bordeaux mixture would. It is nearly as efficient as Bordeaux and perfectly harmless to the berries.

The spray should be put on at the rate of eighty to one hundred gallons to the acre, and under a pressure of at least one hundred pounds. The hole in the disc of the nozzle should be one-sixteenth inch.

Stationary nozzles may be used for the first two applications. When the fruit begins to form, use trailers and apply the spray directly on the berries.

FORMULAS.

Bordeaux Mixture.

Copper sulfate (blue vitriol)	5 lbs.
Stone lime..............	5 "
Water...........to make	50 gals.

Many methods are recommended for making the mixture. The following is handy and practical for the grape-grower:

Dissolve the copper sulfate crystals in water. Then pour the solution into the tank. Fill the tank about three-fourths full of water. Slake the lime in a pail or tub, applying hot water at first. Bring the lime to a thin milk. Strain this mixture into the spraying tank, and add water to make the mixture up to the required amount.

Ammoniacal Copper Carbonate.

Copper carbonate	5 oz.
Ammonium	3 pts.
Water..........to make	50 gals.

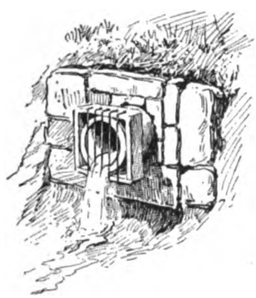
Dilute the ammonium with six or eight times its volume of water. Add the copper carbonate to the diluted solution, and stir until dissolved. Add water to make the required amount.

If large quantities of the above mixture are required, it is more economical for the grower himself to make the copper carbonate. Proceed as follows: Dissolve 12 pounds of copper sulfate (blue vitriol) in 12 gallons of water in a barrel. Dissolve 15 pounds of sal soda in 15 gallons of water (preferably hot). Allow the solution to cool; then add the sal soda solution to the copper sulfate solution, pouring slowly in order to prevent the mixture from working up and running over. A fine precipitate which will settle at the bottom after the mixture has stood about twelve hours is formed. Siphon off the clear liquid above. Wash the precipitate by adding clear water, stirring and again allowing to settle. Siphon off the clear water, strain the precipitate through muslin, and allow it to dry. This is copper carbonate. The above amounts will make about six pounds.

MAY, 1908 BULLETIN 254

CORNELL UNIVERSITY.
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
DEPARTMENT OF SOILS (EXTENSION WORK)

DRAINAGE IN NEW YORK



By ELMER O. FIPPIN

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The regular bulletins of the Station are sent free to persons residing in New York State who request them.

CONTENTS

DRAINAGE IN NEW YORK.

The primary purposes of this bulletin are first, to call specific attention to the intense and wide-spread need of better farm drainage in the State; second, to recommend and urge the substitution of tile drainage for most of the surface drainage in use at present; third, to get in touch with all those persons in the State who have had experience with tile drains and with those who will install them in the future to determine (a) how large the results are which accrue from tile drainage on all types of soil and with all kinds of crops and farm practice; (b) the best methods of laying tile on different soil types; and (c) the cost of tile drainage on different kinds of soil and under different farm conditions.

The general practice of no other single improvement in the management of New York soils promises to give as large net returns as thorough drainage. The cultivated lands of the State have long passed their virgin condition of productiveness and to obtain the largest possible crops, it is now necessary to practice the most thorough and modern methods of tillage. This does not mean that our soils are exhausted and no longer capable of giving the large crops obtained when the land was first cleared. They may be and have been made to produce as large or even larger crops than were first obtained. It means that more exact and thorough methods of soil management must be practiced by the farmer. By means of nature's long course rotation, most of the land had, at that early time, reached a condition of good tilth. By a long continued process of selection, the plants adapted to special conditions — as swamp, sand or clay — had been secured. The soil was loose and open as a result of both the development of plant roots and the accumulation of vegetable mold and humus which were incorporated with the soil through natural processes of cultivation. This large accumulation of organic remains put the soil in good physical condition and tended to keep it so as long as the organic matter was present in considerable amounts. But in the large majority of cases indifferent tillage methods have permitted the loss of this organic matter — humus — to take place more rapidly than the accumulation processes with the result that the soil became lighter colored and less favorable physically to the development of crops. Along with this loss of organic matter and the less thorough permeation by plant roots came pronounced physical changes of far reaching effects. The soil tended more to become hard, the rain water moved more rapidly through or over it and the subsequent rapid drying caused it to become hard and dense. Such soil requires more careful tillage to maintain its former good tilth. This deterioration of physical condition is accompanied by a change in the relation of the soil to the natural rainfall. Variations in the accumulation and movement of

the soil moisture and drainage water become readily apparent and extremes of wetness and drought alternate frequently.

Here comes in the second distinction between nature's method and that of man in utilizing land. He wishes to grow a particular crop and will plant it in a variety of soil including land of a naturally wet condition. This condition he may ameliorate to a greater or less degree by various cultural practices. Nature, on the other hand, accepts the natural condition of the soil, whether it be wet or dry, coarse or fine, loose or dense, and by a process of selection and association, develops on such land the vegetation adapted to growth in such a situation.

The farmer must adopt nature's methods of crop production to a degree, but he may go farther and improve on them in certain directions. He adapts his crops to the soil, but he also attempts to modify the soil to meet the needs of the crop he desires to produce. He does this by drainage, tillage and the use of manures and fertilizers.

Clay soil badly in need of tile draining. New York.

This is the proper order in which always to think of these operations — drainage, tillage and manures — because good tillage can never be practiced unless the land is well drained and fertilizers and manures are of little or no value without good tillage. This is especially true for fine textured soils. Most of the desirable conditions of the soil, which result from tillage, are only obtained in well drained soil and in poorly drained soil, these are more likely to render the bad conditions more acute. In farm practice, a very large amount of energy and money is wasted on tillage and manures because of the failure to recognize this fundamental fact — that the soil must first be thoroughly drained.

A clear conception of the necessity for drainage involves an understanding of the necessary conditions for the growth of plants and the effects of the various tillage operations. Practically all farm crops have the same general requirements for growth. They differ only in the char-

acter or intensity of these essential conditions. They must have food, moisture, heat, light and air and they must be mechanically supported in a congenial manner. All of these conditions, except the light, are modified in some way by the soil which is simply a medium for the supply of the essential factors of growth. Anything which modifies these in a way unfavorable to a particular plant hinders the development of that plant.

Practically all of the crops grown in New York are land plants and are adapted to growing in a moist soil and not in a wet soil. Herein they differ from water plants. Therefore, they will not grow normally in a saturated soil. A saturated soil is one which has all its pores filled with water. In such a soil if the water is free to flow out under the influence of gravity, part of it will pass away. But a large part of such moisture — from 40 to 70 per cent — will be retained by the soil. The soil holds it, causing a film to overspread all of the particles and to fill the smallest spaces. This moisture which is retained is called capillary water and is the form suited to the use of ordinary crops. It can only be lost by evaporation. It gives the soil a nicely moist appearance. It produces the condition of wetness for which the farmer should strive. The retention by any cause of any part of the soil water, which would flow away if free to do so, is directly injurious to ordinary growing crops in proportion to its amount. Drainage is the process of removing this undesirable excess. It must be removed before tillage can be properly practiced and before that congenial and sanitary environment, desired by all our common crops, can be obtained.

New York State has a very large area of farm land on which the drainage should be improved and it is not confined to the areas of an acknowledged swamp or marsh condition. It includes even larger areas now laid out in fields and regularly cultivated to crops.

I. TYPES OF DRAINAGE.

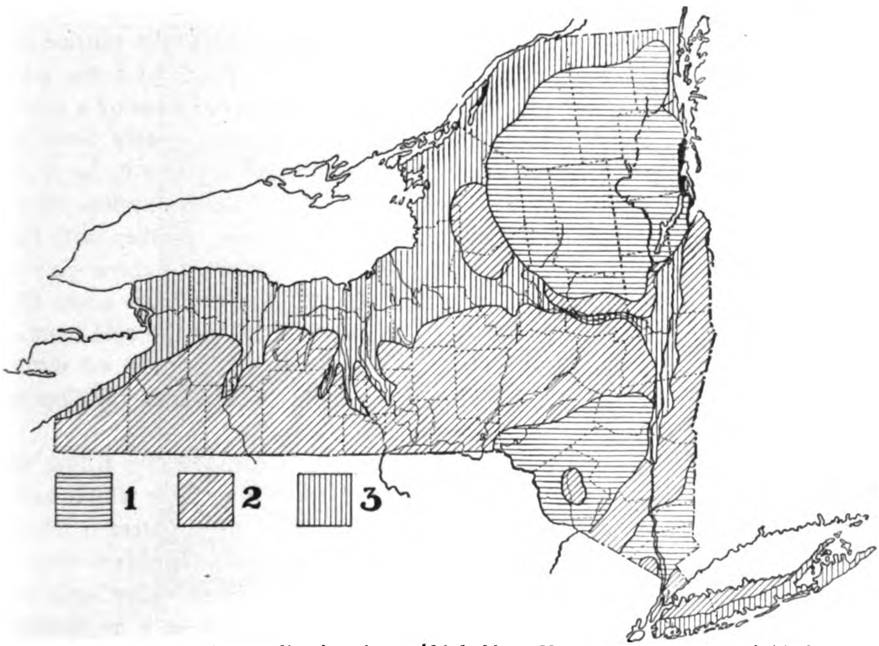
There are two general types of drainage. (1) Open or surface drains, consisting of any sort of depression in which water will accumulate and through which it will flow. In these there is a great range in efficiency depending on their mode of construction, the soil conditions and their state of repair. (2) Closed or sub-surface drains, composed of any available porous stratum through which the water will flow more rapidly than through the natural soil. Nature often constructs such subterranean drains of strata of sand, gravel or limestone directly beneath the low or impervious stratum. Man constructs similar porous strata of stone, wood, tile or any other available material. Of these materials, the tile drains are most efficient and are the ones with which this bulletin is primarily concerned.

A. *General grouping of land according to agricultural value.*

The land of the State may be divided into three groups, the location and relative extent of which are shown by the map on this page.

These are: first, the non-agricultural mountainous land; second, the remaining high, rolling to hilly farm land of the State; third, the more level portion of the State of low elevation where is found nearly all of the heavy clay and the light sandy soil and in addition, the greater part of the pronounced marshy or swamp land.

(1) In the first or *non-agricultural group* is comprised all of the mountainous areas of the State where the country in general is too rough and



The drainage districts into which New York state may be divided.

(1). Non-agricultural land.
(2). Highland sections agricultural land.
(3). Lake plains and river valleys. The most level agricultural land.

broken and the soil covering too thin and stony to permit the practice of farming. These areas are occupied by forests. The only cultivable land occurs in ribbon-like areas in the valleys and is of comparatively small extent.

(2) The second and third groups constitute the farming land of the State. The third group includes the *lowest part of the State in point of general elevation* and in which the largest extent of heavy clay land and of pronounced swamps are found. The soil is not all clay or swamp by any means, but is of a great diversity of textural condition. They include, besides the clay and the muck soil, even larger areas of rolling upland loams,

silt loams and stony loams and more level areas of sandy soil of varying texture. The belt of country skirting the southern shore of Lake Ontario is characterized by an undulating topography composed of rounded, lenticular hills with their long axes arranged in a northerly and southerly direction and separated by depressions which are frequently swampy and generally poorly drained. The clay and the sandy land is generally fairly level. In this area is included much of the best farming land in the State.

(3) The second group constitutes the *remainder of the State* and lies at a *high average elevation* and with the exception of the Hudson Valley portion forms dissected plateaus. It includes most of the highland area in the southern part of the State and with the exception of the large valleys which traverse it, the soil covering conforms fairly close to the outline of the underlying rock surface which occurs usually at a depth of from 4 to 30 feet. The soil is in the main a moderately fine textured loam of a more or less stony character. Large areas on the divides are nearly level or gently undulating but adjacent to the stream courses it is likely to be steep and broken. The undulation is of such a character as to develop many shallow basin-shaped or broad V-shaped areas and these, together with the character of the soil and the structure of the country, produce poorly drained land in abundance. The further fact that over large areas the underlying bed rock is a rather impervious shale and that the soil mantle is thin permits poor drainage to be accentuated by the seepage of water along the surface of the rock forming spring areas on both strongly sloping and on quite level land.

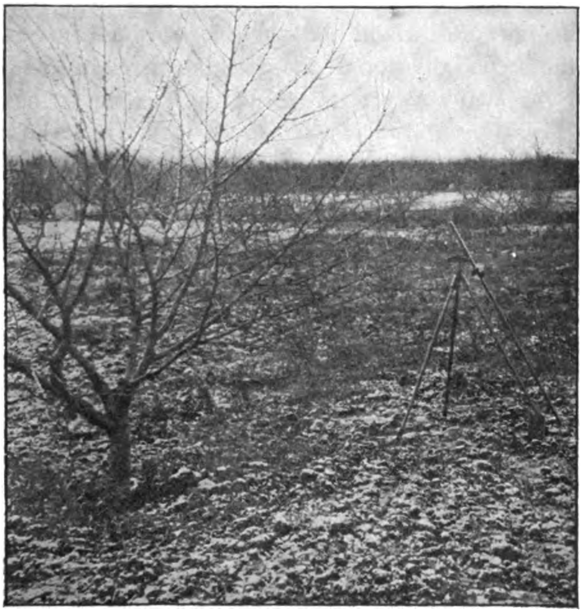
The large valleys have, for the most part, a considerable filling of gravelly, sandy and silty soils often arranged as high terraces which have been more or less completely removed by the action of the stream which occupies the lowest line of the valley and along which is the ribbon-shaped area of bottom land somewhat subject to overflow. These valley soils are sometimes poorly drained as a result of local conditions such as texture and position with reference to the upland slope. It is a common experience to find wet land at the foot of a slope where the valley material joins the main wall of the valley. These lands are rendered wet by the seepage of water down the face of the rock, through or over the thin soil covering.

B. TYPES OF DRAINAGE CONDITIONS.

A general survey of the land of the State reveals three groups of conditions with reference to drainage.

(1) The *pronounced marsh or swamp land* which is of practically no crop value, except for some timber, until better drainage is established. In the aggregate such land is of large extent in the State and is found most abundantly in the second division. It occurs as numerous, usually small, irregular areas, in some places occupying the pass between drumlin

hills, along streams which occupy such positions and in other places it forms a fringe around lakes or occupies the site of former lakes, which have been filled up to this swampy condition. The first condition is typefied by the numerous swampy areas in Wayne county; the second is typically developed in southern Monroe county and around Oneida lake. Both phases are most largely developed in the region adjacent to Lake Ontario. Similar conditions are also found in other parts of the State, the most notable examples of which are the Walkill valley in Orange county and the southern shore of Long Island where much land is subject to tidal overflow and the reclamation of which often involves the con-



The result of poor drainage in a peach orchard
Many trees missing.

struction of levees. Much of this marshy or swamp land consists of large accumulations of organic remains forming muck and peat. The remainder consists of variable material rich in organic matter derived from the wash from the soils at higher elevations.

These areas are low and flat and it is frequently very difficult to get a satisfactory outlet. They also involve several practical difficulties in the construction of drains. They are so fully saturated with water that its removal involves the readjustment of the soil, particularly if it is muck or peat. This readjustment should be permitted to take place before any form of closed drain is installed. The conditions implied by the term "quick sand" also require similar treatment.

This land is wet, not because of its impervious character, but because its location is favorable to the accumulation of water from higher soils either by surface flow or through springs. The reclamation of such land involves the control of this drainage water from other land in such a way that it does not interfere with the low land.

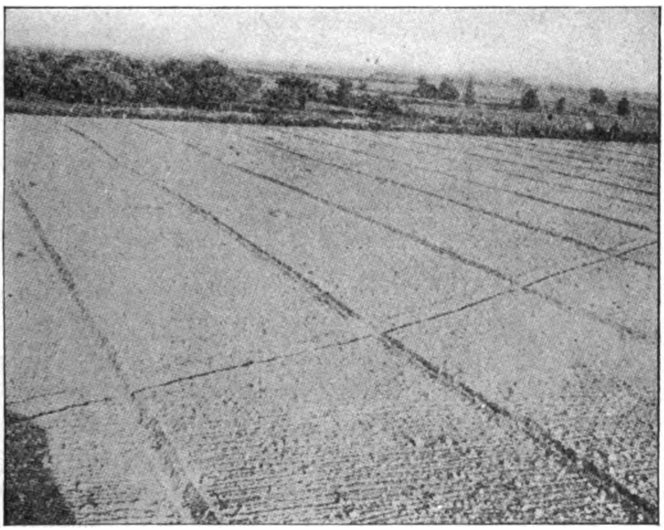
The soil in these marshy places is often the most productive in the country when well drained and constitute a highly important part of the great soil reserve of the State. In some of the Central States where large areas of similar soil existed, which have been drained, they give some of the largest yields of the staple crops as well as of truck and other special crops. Such, for example, is the Clyde series of soils of New York, Ohio, Michigan, etc., and the Miami black clay loam in the north central states.

(2) In the second division of the State, as made in this paper, is found *nearly all of the heavy clay soils.* Much of this region has been formed under lake conditions during earlier times with the result that the sediments brought into these lakes, either local or general, were sorted and deposited in strata of differing texture. In some places they are clay, in other places they are silt, sand or gravel. Since the clay represents the most quiet conditions of deposition it forms the most nearly level land, any undulation being the result of the uneven surface upon which the deposit was made. Consequently much of the truly clay soil embraced in the Dunkirk, Clyde, Vergennes and Galveston series of soil has an even, and often, flat surface. The impervious character of such material, combined with its level topography, permit the retention of the rainfall on the surface. It differs from the first group in that there is much less accumulation of the rainfall from other areas of soil. There is some accumulation of water due to the undulations of the surface, but in the main the problem is one of handling the rainfall which normally falls upon the clay area. This further important observation should be made. On heavy clay soil, the subsoil is frequently not saturated with water in the sense in which sandy soil is saturated. The water is held on the surface. It moves through the soil very slowly, an important factor in its removal being evaporation. Such water is especially injurious because of its "stagnant" condition. It very completely cuts off the soil from free circulation of air.

This water must, in the main, be removed by surface methods. This does not necessarily mean open ditches. These are now very generally used in the State on such land and it is one of the purposes of this bulletin to call attention to the better method. This method is the use of tile drains. On land as level as are many of these clay soils, the open ditches are often hastily and poorly made. They are rough and in a short time become clogged by weeds. Their fall is too small to permit any rapid movement of water, and further, they generally have a ridge of earth on either side which hinders the entrance of the water. These disadvantages are in

addition to the inconvenience to tillage and harvesting operations and to the general inefficiency of such methods of drainage as practiced.

On the other hand, the use of tile drains under these circumstances is a distinctly different proposition from what it is on coarser textured and loose soils of silt, sand and gravel. The most obvious advantages of the tile are that they will be well laid and will afford a clean, smooth channel for the flow of the water. With such a smooth channel, the water moved by a small fall will be much greater than in the average surface ditch. Further, the average surface drain is a shallow channel made by a single shovel plow of some sort and takes no account of the variations in elevation of the land further than to follow the visable water course, which is often entirely inadequate. Tile drains, on the other hand, are laid to grade with a fairly uniform fall on any course.



A thorough system of surface drains in a newly seeded grain field.

As stated above, the methods of tiling coarse textured soil do not apply to fine textured soil. In the former case, they are laid fairly deep to lower the water table below the root zone. Here is the first indication that a sub-drainage system should always be adapted to the local conditions of soil, slope and general drainage. No fixed rules can be given. But in the matter of depth this principle applies on clay soil. The tile should be laid as shallow as is consistent with the climatic conditions and the fall. The aim is to remove the surface water as quickly as possible and before it does injury to the crop if one occupies the land. To do this, there must be easy access of the water to the tile. For this reason, they should be shallow — two feet or less — and should be connected with the surface by means of stone filters and other porous media which will be described further along in this bulletin. The water enters the tile through the joints and in clay soil it reaches these through the cracks, decayed root passages

and animal burrows. The better drained the soil the more numerous will be these openings. Consequently it is proper to find a gradual increase in efficiency in such a drainage system for a number of years after its installation.

In laying drains shallow consideration must be given to the effect of frost. This involves both the preservation of the tile and their alignment and grade. Through co-operation with farmers throughout the State, it is hoped to determine experimentally by means of trial systems the importance of these difficulties in practice. The available data is not of a sufficiently convincing character. There is considerable reason for believing that if the best quality of hard burned or vitrified tile is used there will be very little difficulty on either score. This idea is supported by the practical experience of farmers, although it is a common opinion that a tile drain should never be permitted to freeze.

These suggestions apply to all that great belt of country along lakes Erie, Ontario and Champlain and in the Hudson valley. On the large areas of clay soil here found, surface drainage is almost universally practiced.

All clay formations are likely to be underlain by a more coarse textured stratum consisting of either sand or gravel. In planning a drainage system on clay soil, it is always important to examine the soil to a depth of three or four feet at a number of places to determine whether such a sandy layer is present. If it is found within 3½ feet the tile should be placed as near its surface as possible, since the soil water will reach the tile most rapidly through this porous stratum. Under such conditions it is especially necessary that filter basins connected with the surface in low places should be constructed to hasten the removal of surface water.

Conversely, on sandy soil observations should be made to determine the presence or absence of a considerable clay stratum beneath the sand. If it is found within from two to four feet of the surface, the tile should be laid on top of the clay.

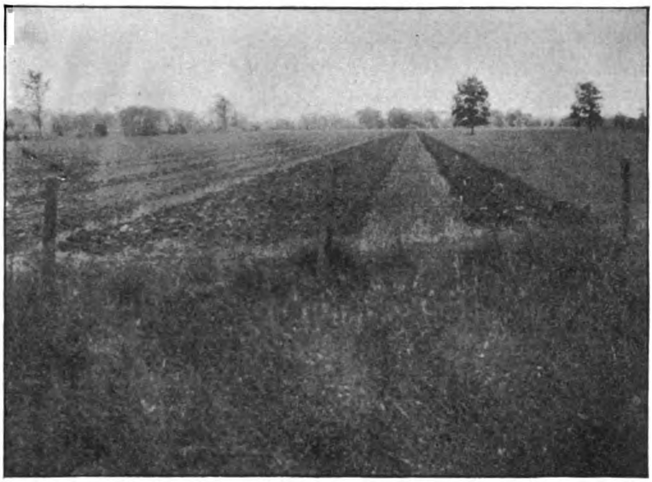
Associated with the clay soils are considerable areas of sand and sandy loam soil, some of which have poor drainage. The areas are usually small and are the result of some local peculiarity of structure. On these the generally accepted principles of drainage apply. The tile should be placed at a depth of from three to four feet and at a greater distance apart than on clay soil.

(3) The third drainage division of the State, includes all of the ***upland soils of rolling and hilly topography*** and is much larger in extent than either of the other divisions. It is also the division on which the least drainage is practiced at present. In many places some stone drains have been constructed with the stone picked from the fields. These systems are usually of small extent and in the main have been in the ground for

many years and they have frequently been rendered ineffective by the burrowing of animals and from other causes.

There is also much less feeling of the need of underdrainage on high rolling lands than on the low flat clay lands or marshy lands. An excess of water does not persist at the surface for so long a time as on the other classes of soil and therefore its effects are not so readily apparent. There is also the feeling that any land which has a strong surface slope cannot be in need of underdrainage since the surface drainage is entirely adequate. This idea should be carefully examined before acceptance. Very frequently it is entirely wrong. A very much larger part of such hilly land would be benefited by drainage than is generally believed.

The land included in this division occurs in both the second and third group of the State. It may, however, be divided into two phases. These are, first, the low, rolling areas of stony loam to clay loam soil south of Lake Ontario as far as the latitude of Geneva or a little beyond and through the Mohawk valley. Also the upland soils in the Hudson valley and the northern part of Long Island. These generally have a subsoil of variable texture and structure. Sometimes it is gravelly and sandy, but often it is a dense stony or gravelly loam quite impervious to water. In such cases drainage is needed. In this phase of soil conditions, drainage is not as frequently needed as in the second phase of soil conditions.



Clay soil being plowed in eight step lands. The "dead furrows" serve as surface drains.

The second phase includes all of the high, plateau soils of a rolling or hilly topography and comprises practically all of the second group in which the soil conditions are divided. Here the Volusia series of soil predominates. Their surface conforms closely to the surface of the underlying rock. The subsoil is usually fine textured, but stony and rather compact and impervious. This condition is increasingly true toward the southern part of the State on the Volusia silt loam. The soil, to a depth of from 12 to 18 inches, is generally loose and fairly friable but below

this depth, the subsoil is inclined to be very impervious to water, which condition is aggravated by the presence of many shale chips. This makes a very compact layer, which holds the water and resists the entrance of plant roots. On such land the surface soil readily absorbs the rainfall. But the total amount absorbed is limited by the shallow depth of the porous layer and the removal by percolation of the excess is very greatly hindered. Its removal is effected slowly by evaporation and by percolation through the soil along the surface of the dense subsoil. This condition tends to keep the subsoil wet so much of the time that it does not have an opportunity to become loosened up by drying or the action of plant roots. Further, the saturation of the soil during so much of the crop season, greatly hinders the extension of the plant roots. They develop shallow and are quickly affected by periods of dry weather. Cultural operations are longer delayed by the wetness of the soil and the removal of so large a part of the moisture by evaporation, keeps the soil cold and materially changes its climate. This, in turn, reacts seriously on all of the functions of the crop and consequently upon the profit.

There are also many swales or shallow depressions, as mentioned above, where the drainage is defective because of both the impervious character of the soil and the accumulation of surface drainage. These areas would be especially productive if drained. Any drainage system that is established should begin with these low places and may be extended to higher land as its benefits are demonstrated. On all this hill land the system of tile drains will be determined by the surface features, but one important principle should be observed. The drains should extend directly down the slope rather than diagonally across the slope. If they are place diagonally, their efficiency will be much reduced by their limited drafts on the down hill side and by the leakage from the joints where the tile passes through moderately dry soil.

II. SOME HISTORICAL PHASES OF DRAINAGE IN NEW YORK.

The early drainage practice in New York and in America in general was very largely modeled after the English practice of the first half of the nineteenth century. The so-called government scheme of drainage was then in vogue and two general schools of practice were recognized. Mr. James Smith of Deanston, advocated shallow drains — not to exceed 30 inches — and as frequent as from 10 to 24 feet. Josiah Parks, on the other hand, advocated deep drains — 4 feet a minimum — and a greater interval — from 21 to 30 feet apart. Both gentlemen advocated the systematic placing of the drains at these respective intervals in naturally dry soil as well as in wet soil. That is to say, very little consideration was given to the variations in the soil and the local conditions. Consequently such promiscuous burying of tile often resulted in large expenditures of money without corresponding returns. The failures of drainage to pro-

duce net returns in such cases has probably been more effective than any other one thing to prevent the more general and thorough adoption of the practice. Necessarily the improvement involves a very considerable expenditure of money per acre and the common feeling that the tile must be placed near together and at regular intervals to be at all effective, has deterred many from attempting the improvement. Drainage, like almost any other farm practice, cannot be performed by a "rule of thumb" but requires intelligence and care to adapt it to the local conditions of soil, rainfall, climate, surface features and seepage in order that the largest net returns may be secured.

(1) *John Johnston.* New York may well take pride in the fact that she was the pioneer in America in the practice of tile drainage for agricultural purposes. That distinction was given to her by Mr. John Johnston, whose likeness at the age of eighty years appears on this page. There is the further and more important distinction that Mr. Johnston was especially successful in the practice and the great increase in crops, which resulted on his farm after he had installed tile drains, may still be quoted as among the most clear and forcible examples to be had anywhere of the money benefits as well as the personal satisfaction which results from tile drainage.

John Johnston at the age of 80 years. He laid the first tile drains in America about 1837.
(From an old file of American Agriculturist.)

He was a Scotchman who came to America and purchased a farm about four miles southeast of Geneva, in Seneca county, in 1821. It may be presumed that his methods of tillage and of general farm management were about as careful and thorough in the early years of his venture as in subsequent years. But he says, "I never made any money at farming until I had tile drained my land." He laid his first tile in 1837 and the 300 acres of land which he farmed contained at the time of his death in 1880,

between 60 and 70 miles of tile drains. They were gradually installed during thirty-five years and are as clear a proof as can be had of the conviction of Mr. Johnston that tile drainage pays when properly done. He was a man of limited means and depended upon the returns from the land for the money to make the drainage improvement. The first tile were installed with borrowed capital and after that time he depended upon the profits from increased crops on one piece of land, which he had drained, to install the drainage on the next field. So convincing were his results, not only to himself but also to his neighbors, that from 1852 to 1860, Mr. Swan — a man of means and a son-in-law of Mr. Johnston who owned 335 acres of land adjacent to the Johnston farm on the north and since widely known as the Rose Hill estate — completely and thoroughly drained this land installing, it is said, about 75 miles of tile.

FIG. 188.—*Outlet of one of the systems of tile drain on the Johnston farm as it appears at the present time. The U tile at the left has served in the outlet for upwards of fifty years. In the background is shown the type of land drained.*

The drainage system on both of these farms, while resembling in some respects the English systems, differed in this fundamental point, that they were adapted to the soil and the natural drainage conditions. While Mr. Johnston's ideals of thorough drainage may have been, as he says, from two to four rods apart according to the character of the soil, he very carefully studied the surface features of the underground seepage and adapted the size, depth and distance apart of the tile to these conditions.

The land drained by Mr. Johnston lies adjacent to the head of Seneca lake and while no thorough study of the soil types in this region has been made, the soils appear to belong to three general types. These are the Dunkirk clay next to the lake and Dunkirk loam higher on the slope with some phase of dark alluvial loam in the depressions. The general surface is rolling as shown in figure 188 which is taken from near the lake looking toward the farmstead. There are no sharp breaks but gentle undulations giving a range in elevation between different parts of the farm of perhaps 80 or 100 feet. The clay type is especially fine textured and naturally dense and this property is clearly shown in a large area of such soil a mile or more to the north of the farm at the head of Seneca lake. Much the larger part of the farm consists of the Dunkirk loam which is

a rather heavy phase of the type verging on clay loam. These types belong with the second drainage division made in the State.

The third type of soil embraces the depressions between the ridges which receive the natural drainage from the adjacent higher land along with the soil wash. In such places water loving vegetation throve and gave them the characteristics of marsh or swamp. But it was not this very wet land that Mr. Johnston first drained. He says, "Encouraged by a considerable increase of products derived from my farm from draining, I determined to extend the system as rapidly as convenience and circumstance would permit. Upon examining, it appeared necessary to possess a piece of ground belonging to a neighbor, that I might secure a good and sure outlet for the water from my upland fields that required drainage in places. With this in view, I purchased ten and three-fifths acres of low land saturated with water. A part of this land, say about four acres, within from twelve to eighteen inches of the surface was a black vegetable mold lying on a stratum of clay of the same depth under which I found a hard bottom for my tiles not over three feet in depth. I felt persuaded that those ten acres were wet from my own upland as well as from my neighbor's wet land adjoining. The first ditch I dug was directly on a line betwixt the land I got from my neighbor and that he still owns. This I found cut off all the water on that side. I then commenced draining that ten and three-fifths acres; also about thirty acres of upland. A large proportion of the upland did not require draining. In the two pieces which made into one field containing about forty acres I laid 1072.5 rods of drain which have drained the whole extent in a thorough manner. * * * The first year after completing the drains in this field, the whole or nearly the whole, upland and all, was planted to corn. The season was not favorable for that crop in this neighborhood, yet the crop was fair, say forty bushels shelled corn to the acre. The low ground was excellent where nothing but coarse grass grew for twenty years before. This year, 1851, I harvested from this field a crop of wheat and a heavier

FIG. 189.—*Gold and silver pieces presented to John Johnston in recognition of his services to agricultural interests in the practice of tile drainage.*

crop I never saw stand up. * * * The wet ground got from my neighbor was the source of much curiosity to all around as none would believe that wheat could be ripened on land so long saturated with water. The result was a crop of wheat from that ground abundant in quantity and excellent in quality."

Such a combination of conditions is quite typical of much of the State. The marshy land belongs to the first drainage division. When Mr. Johnston purchased his farm it was said to be "poor and worn" and the first seventeen years of his experience with it were calculated to support that conclusion since he confessed that he could make no money. But by careful study, he perceived to what most of his trouble was due. He observed the excess of moisture and the "winter heaving" which raised his

FIG. 190.—*The Johnston homestead near Geneva, N. Y. Buildings erected before* 1825.

crops out of the ground. He said in 1852, "I was, many years ago, satisfied of the necessity of removing in some economical way the surplus water which saturated the soil and too often interfered with the growth or maturity of the crop; not only with wheat but also with grain and clover."

The general necessity for drainage had been impressed upon him very early in life by his grandfather in Scotland, who said to him "Verily all the airth needs draining." On his way to America and before he was out of his native land he observed the burning of tile for drainage purposes and when he found his own soil "cold and wet" he apparently remembered his grandfather's advice and the "crockery being burned in the Scotch field," for in 1835 he imported from Scotland a few tile and initiated the making of others. Through his efforts his neighbor, John Delafield, imported a Scraggs tile machine from England in 1848. His first tile were of the horseshoe and sole type. Later he used round tile.

Unfortunately there does not appear to be any plot showing the loca-

tion and arrangement of the tile put in by Mr. Johnston. We know of them only from his own statements. But how effective was his system is well known from the results which have been observed from the very beginning of his work along this line. He was widely recognized in the State as an authority on practical drainage matters. In 1852 he was awarded first prize by the New York State Agricultural Society for a paper giving an account of his methods and results in tile draining. For

FIG. 191.—*Wheat stubble on Johnston farm which yielded 44 bushels per acre in 1907. Note the well granulated condition of the lump of soil at the left of the cut.*

a number of years he was chairman of the committee on drainage of the above named society and did much in that capacity for the extension of the practice. It is interesting to note in the proceedings of this society in the fifties and sixties how the reports on draining center in the Seneca Lake region presumably largely as a result of Mr. Johnston's example. The esteem of the man and the recognition given his work by his associates is shown by the several gold and silver pieces presented to him from time to time by different gentlemen and associations in the State. Cuts of

these pieces made from a photograph by C. G. Elliott are shown in figure 189.

The productiveness of Mr. Johnston's farm is widely known. A neighboring farmer writing in 1866 remarked that he was going to build a barn "after my land is drained and I have had two or three of John Johnston's wheat crops." The farm was devoted primarily to wheat but hay and some other grain was also grown. The yields of all these crops was unusually large for the region and also for the present day. For 1847, he reports a yield of 83 bushels of shelled corn, considered the largest ever raised in the county up to that time. On the same piece of tile drained land, he reports similar large yields of barley and hay in subsequent years. Nor has this large productiveness disappeared up to the present time. Mr. Charles Rose Mellen who has owned the farm for a number of years, also gets similarly large yields of the same crops grown by Mr. Johnston. Mr. Mellen takes much pride in the historic features of the place as well as the results of the tile drainage. He considers the tile still in good working condition. Occasionally it is necessary to replace a tile but that they continue doing good service, after fifty or more years, is shown by figure 188 which is a view of the outlet of one of the large mains where two 6 inch U tile were laid side by side. The tiles were flowing full of water and on the left bank is one which has served at the outlet for over fifty years and is still in a good state of preservation even under the unusually severe conditions to which an outlet tile is subjected. A nearer view of this is shown in figure 215. The surface features of land drained by this system is shown in figure 190.

Mr. Mellen showed the writer a piece of wheat stubble which produced during the season of 1907 an average of 44 bushels of wheat over a number of acres. Figure 191 shows some of the stubble and a block of the soil illustrating its well granulated condition. The stubble was so even in character that there was very little choice in selecting the place for the photograph. Mr. Mellen reports that all his crops yield in the same generous proportions. In figure 190 is shown the Johnston homestead built in 1822 and also occupied by Mr. Mellen until 1908 when he moved into the new residence shown in the background in figure 188 which also shows the old residence. All this is the product of the land.

But it would be misleading to leave the impression that all this large productiveness is the immediate result of tile draining. It is an example of the point made above, viz., that good drainage should precede good tillage and the use of manures. Mr. Johnston was a good farmer. He practiced, as does Mr. Mellen, good tillage. He grew clover and he kept some stock, the manure from which was carefully applied to the land. And by the assistance of thorough drainage, he obtained large returns from these. Mr. Johnston died at Geneva in November 1880 at the age of ninety years.

(2) *Theron G. Yoemans.* The name of John Delafield has been mentioned as the importer of the first tile machine — a Scraggs. One other man deserves recognition in this group. Theron G. Yoemans of Walworth, Wayne county, very early became a disciple of Mr. Johnston in the matter of tile drainage and these three men — Johnston, Delafield and Yoemans — were assiduous in spreading the gospel of better drainage. Unlike the soil around Geneva, Mr. Yoemans' farm of over 300 acres consisted mainly of Miami stony loam and the surface is rather more rolling than the land around Rose Hill. It may be classed with the first phase of the third group made in the State. The general lay of the surface is shown in figure 192. It will be noticed that the differences in elevation are very considerable and will amount to a hundred feet or more within rather short distances. But the slopes, while steep, are never abrupt and are seldom

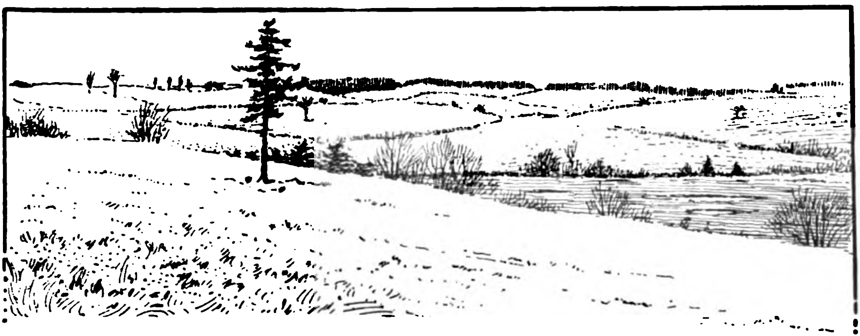


FIG. 192.—*Rolling character of surface in Miami stony loam region adjacent to Lake Ontario. Note intervening swampy depression, which is characteristic.*

too steep to be tilled. Another characteristic of this Lake Ontario region is shown in this figure 192. Between the hills is frequently found marshy or even swampy land. Figure 194 shows at short range an area of muck soil flooded because of the inadequacy of the open ditch through the center and which could very well be made large enough to handle the drainage and preserve the crops. But Mr. Yoemans did not begin tile draining the low land. He was a fruit grower and nurseryman and did his tile draining on the slopes of Miami stony loam adjacent to the village of Walworth. Probably one-half or more of his farm was in fruit and his dwarf pear orchard has gained wide renown, both because of its early success and the thoroughness with which the land on which it stood was drained. The trees stand 10 feet apart with a tile drain between every other row at a depth of from 2 to 2½ feet. The trees were planted in 1852 and almost every one lived until a year or two ago when part of them was removed because they seemed to have become too old to bear. Some of the trees still remain large and thrifty. Mr. Yoemans said that on much of this sort of land many trees were killed by freezing of the soil but that drainage remedied all of this.

In 1852 Mr. Yoemans was awarded second prize for a paper on drain

age at the same time Mr. Johnston was awarded first prize. Accompanying his paper, which appears in the transactions of the New York Agricultural Society for that year, is a plot of the tile drains installed on a piece of land of twenty acres now occupied by healthy old apple trees set by him and this plot is reproduced in figure 193. Like the Johnston farm most of the tile are still in good working condition except that some of the outlets have become closed. The marked beneficial effects of the drains is still recognized by the present owners. Ninety acres of the farm which had 65 acres of bearing orchard including the Dwarf pear orchard set by Mr. Yoemans were sold, a few years ago, to the present owner, Mr. G.

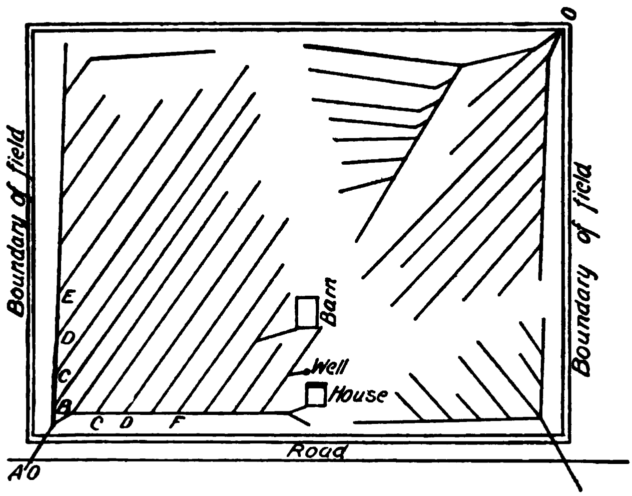


FIG. 193.—*Drainage system of 1200 rods on 20 acres of Miami stony loam. Yoemans farm, Walworth, N. Y. Arrangement determined by topography of land. Sizes of tile: A-B, three 4-inch tile; B-C, two 3-inch tile; C-D, one 3-inch tile and one 1-inch tile; D-E, one 3-inch tile. Remainder of system, one 2-inch tile.*

R. Wignalls, at a very substantial price. So that it may be considered that a very considerable degree of permanency attaches to this type of land improvement.

In spite of the fact that New York State was the pioneer in tile drainage in America, she has fallen far behind several of the newer states of the central west in this type of improvement. In these states where existed large areas of land entirely too wet for farming purposes without artificial drainage, tile draining has been very generally adopted as a necessity, not only on such swampy soils but also upon the upland soil.

New York State needs to recall her early prestige and to remember that very large areas of her soils are not yet beyond the need of better artificial drainage and particularly of tile draining and that large net profits as well as much satisfaction awaits those who take up this improvement with intelligence and discrimination. Some of these benefits may now be summarized.

III. BENEFITS OF THOROUGH DRAINAGE.

Because of the fundamental character of the process of drainage, its effects are numerous and far reaching. Ten of the most important may be given as follows:

(1) *Drainage removes the excess of water* from the surface and from the pores in the *soil* thereby rendering it *more firm*. The presence of the excess of water renders the soil unable to support any considerable weight, because the moisture acts as a lubricant between the soil particles permitting them to move freely upon each other. Therefore, such soil is soft and boggy.

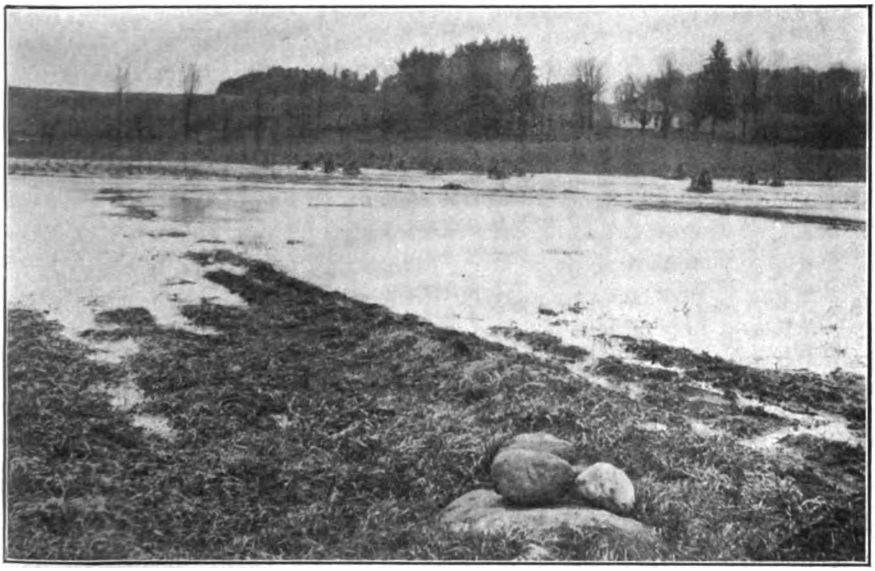


FIG. 194.—*An inter-hill area of much soil in Wayne county greatly in need of better drainage. The flooded condition is the result of a poorly constructed outlet ditch.*

This same free movement of the particles is exceedingly injurious on all except sand or gravel soil because of the undersirable physical condition brought about. The small particles are moved into the spaces between the larger ones, thereby forming a more dense mass of soil. This is known as the puddled condition and when such soil is permitted to dry naturally it becomes exceedingly hard and refractory. Such a condition is generally recognized as undesirable. It is directly opposed to the granular condition of the soil where the particles are grouped in small aggregates and which favors the production of good "tilth." Poorly drained soil, therefore, has the two-fold disadvantage of lack of stability or firmness and great susceptibility to physical modifications injurious to most farm crops. Such injury may be caused by any tillage operations, by tramping and by the natural drying of the soil.

(2) *Drainage is directly operative to change an unfavorable physical condition into a desirable one,* as well as to reduce the tendency to a bad physical condition of the soil. It may bring about the change from a puddled to a granular soil. Such physical changes are most pronounced in fine textured soil. The change is produced primarily by the alternate wetting and drying to which well drained soil is subject. Poorly drained soil is usually in a bad physical condition. It is compact and impervious. This shows that a permanent or long continued wetness prevents the formation of the loose granular condition which is desired. On the other hand, continued dryness produces no important change in the physical condition of the soil. It is the alternation from the wet to the dry condition which produces the readjustment of the soil particles. In nature such an alternation of wetness and dryness is produced on soil where adequate provision is made for drainage. The rain comes periodically producing the wetness which is followed by drying days during which the soil loses more or less of its moisture. In a saturated soil, the particles are partially floated. As the water is removed the film first breaks across the large spaces. It breaks along any natural line of weakness resulting from a different texture or structure, or a root cavity or animal burrow. A film of moisture then surrounds a large number of particles. It may be a mass a foot in diameter or it may be one so small as to be almost invisible and including only a few hundred particles. As the moisture continues to be removed by evaporation or other means, the film is continually drawn tighter around the group of particles and tends with considerable force to move them nearer together in the same way that — to use a common example — the hairs of a brush are held together when it is dipped in water and then removed. The inequalities in the mass of soil permit breakage of the film into smaller and smaller areas with the result that new centers of contraction are produced. This contraction is clearly shown by the checking of a clay soil upon drying. The difference between a cloddy soil and a soil in good tilth is in the size of the granules. In the puddled soil the lines of great weakness are few in number with the result that a few centers of contraction produce a few large clods instead of a very great number of fine granules. The numerous lines of great weakness are gradually produced by this process of alternate wetting and drying and their production is facilitated by the presence of plant roots, by frost, by tillage and by organic matter. It is well known that the tilth of a soil rapidly improves as a result of drainage and it is the result of the operation of all these forces and conditions at the foundation of which is drainage.

(3) Contrary to a frequent belief, *drainage increases the amount of moisture available to crops.* This is the result of two factors. First, it has been shown under two, above, that the granular condition is increased and therefore the total amount of pore space in the soil is increased. When the soil is granulated to the condition of good tilth, the total capillary

capacity is increased. The soil is then able to both readily absorb the rainfall and to retain a larger proportion of it than would otherwise be possible, against the time of dry weather. Second, the wider and deeper distribution of the plant roots in drained than in wet soil puts them in reach of a much larger reservoir of moisture. This effect is well known to those who have had experience in tile drainage. Mr. Johnston was aware of the effect since it is reported that his Dutch neighbors laughed at him for "burying crockery," saying his crop would be "all dried up before it was half grown," but they remained to be amazed at the great superiority of Mr. Johnston's crops over their own at harvest time. Drainage is a desirable practice for dry weather as well as for wet weather.

(4) *Drainage promotes the aeration of the soil,* that is, the exchange between the soil air and the external air. A supply of oxygen is necessary to the proper growth of the living organisms in the soil. Such a supply is largely, if not entirely, excluded from a saturated soil. The removal of the water makes a place for air and the granulation or loosening-up process which occurs facilitates the movement of the air into and out of the soil. The supply of air increases the food available by its direct action on the minerals in the soil and by promoting the growth of desirable bacteria. It also hinders or prevents the growth of many undesirable bacteria.

(5) *Drainage permits the soil to maintain a higher average temperature* than is possible on wet soil. This effect is well known and is generally recognized. Not only has the increased temperature been observed in practice, but it has been demonstrated experimentally to be a very considerable amount. A clay soil holds more moisture than sandy soil and from this fact has arisen the descriptive term "cold soil" applied to clay and "warm soil" applied to sand. The dry soil in each case requires nearly the same amount of heat to warm equal masses, the difference in temperature resulting from the difference in amount of moisture retained under field conditions. How great is this difference in temperature which may result from poor drainage is shown by the following calculation based upon well known facts.

The evaporation of one pound of water from a cubic foot of compact clay, which is saturated with water, absorbs enough heat to lower the temperature of the cubic foot of wet soil 21° F. The evaporation of the same amount of water from a cubic foot of saturated sand soil would be sufficient to lower its temperature 25° F. If, on the other hand, the heat necessary to evaporate one pound of water is used to raise the temperature of the soil containing only the optimum amount of capillary moisture the temperature of the cubic foot of clay would be raised 29° F. and that of the sand 32° F. And if all of the excess of water in a cubic foot of either material were removed by evaporation, enough heat would be used to raise the well moist clay through 380° F. and the sand through 300° F

Such marked effects are supported by the observations of King, Parkes and others. Parkes found in the peat bogs in Lancashire, England, that at a depth of 7 inches the drained soil was 15° warmer than the undrained soil and at a depth of 31 inches the drained soil was still 1.7° warmer. John Johnston wrote in 1853: "Such fields (undrained) must generally be left late in the spring — perhaps too late to work favorable — and in the autumn the frost will inflict an injury." On the Yoemans farm it has been observed many times that the oat crop may be planted in well drained land before adjoining land of the same kind is in condition to plow and in the spring it is commonly observed by farmers how the seed in the wet spots is delayed in appearance above the surface.

These latter observations emphasize one other very important effect of drainage in this connection. It lengthens the growing season by permitting the land to be cultivated and seeded earlier in the spring and by keeping up the temperature in the fall sufficiently late to ward off early frost. In the southern part of the State on the high hills where it is difficult to mature corn even in the favorable seasons it may be readily seen how important to the farmer is this extension of the growing season. In many cases the difference is that between a successful crop and a failure.

(6) *Drainage increases the available food supply in the soil.* This results from the effect of drainage on the moisture retaining capacity, the temperature, the aeration and the growth of soil bacteria. The admission of air acts directly on the minerals as an oxidizing agent, thereby rendering some of them more soluble. The increased temperature increases the solution processes and both the aeration and higher temperature promote the larger growth of soil bacteria, which are vitally related to the plant food supply. It is through their action that the organic matter in the soil is decomposed. The accumulation of peat and muck in boggy places is the result of the

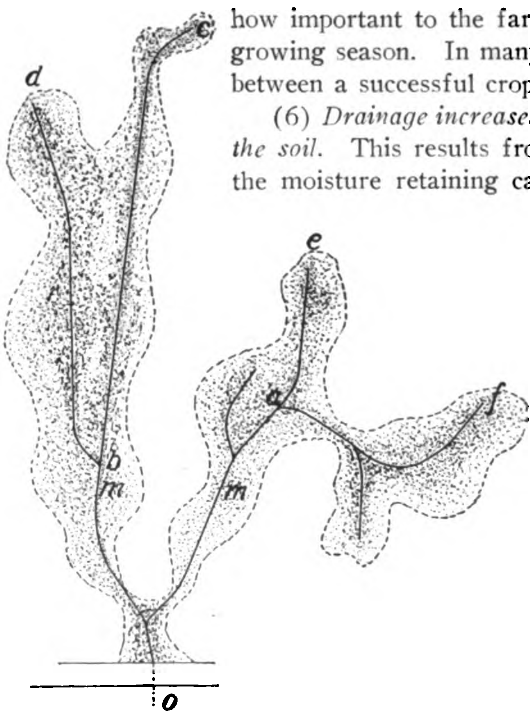


FIG. 195.—*Drainage system adapted to small wet areas of fine sandy loam soil. Wetness is in proportion to shading. Distances: o–c, 675 feet; o–f, 558 feet. Sizes of tile, o to a and b, 4 inches. Remainder of system, 3 inch.*

killing of most of these minute organisms by the soil conditions. One of the first principles in improving such humus soils is to bring about such conditions as will insure their presence and promote their growth.

The first and most common action of organisms is the decomposition of organic matter by which carbon dioxide is produced. This carbon dioxide in turn greatly assists in the solution of the mineral. They also promote the same process in other ways. Further and even more important, if possible, is their relation to the supply of available nitrogen, that is, nitrates. This compound, which is required by all ordinary farm crops, is formed through the action of several forms of bacteria all of which require air and considerable heat. Some of them live on plant roots such as the nodule bacteria of clovers. Others live independently in the soil. The exclusion of air by excess of water not only kills most of these desirable forms, but it promotes the growth of certain other undesirable organisms which destroy available nitrogen and organic matter, often with the production of acid products directly deleterious to higher plants. So that there is a double reason why drainage should, at all times, be as thorough as possible — namely the food supply and such a condition of the organic matter as promotes the best physical condition of the soil.

(7) *Drainage enables the plant to make a better use of the food and moisture supply in the soil.* The roots of most farm crops will not develop into a saturated soil. If the water table is at or near the surface, the roots spread out laterally instead of penetrating deeply. The direct result is that when the water table is materially lowered later in the season, the roots are left high and dry and quickly reflect drouthy periods of weather. On the other hand, if the soil is well drained, they develop much more deeply and thereby are connected with a larger moisture reservoir and can withstand without injury a much longer period without rain or irrigation. Their development assists in the improvement of the physical condition of the soil. Equally great is the advantage to the plant with a deep root system of the larger feeding ground. While there is some movement of the food in the soil moisture to the roots, it is equally important that the roots extend themselves into fresh areas of soil. Indeed it has sometimes been suggested that this extension of the roots is more important than the movement of the food to the plant with the moisture. Both the food and moisture considerations are certainly important in the production of maximum crops.

(8) *Drainage greatly reduces the injury to winter crops resulting from "heaving"* or the freezing of large amounts of water in the soil. This process raises the upper layers of soil, carrying all shallow rooted plants with it, and if some of their roots happen to be fastened in the subsoil,

these may be broken off. Such effects are most noticeable on tap-rooted plants, such as the clovers, but it is almost as injurious to the grass and grain crops. Nor is the injury of heaving confined to small plants. It extends to trees and even to fence posts, the latter being lifted out of the soil by successive freezes. This effect of drainage in reducing or preventing "heaving" is very generally known by men of experience in the practice. Speaking of the effect in 1851, Mr. Johnston said, "Heretofore many acres of wheat were lost on the upland by freezing out, and none could grow on the low lands. Now there is no loss from that cause." Mr. Sanford Howard of the Boston Cultivator, in writing in 1852 of the effects of drainage on Mr. Johnston's farm, says. "This year when much complaint is made of wheat 'freezing out' and of the weevil or white midge having greatly injured it his crop will, according to the best judges, average over thirty bushels per acre. There was no freezing out here; every grain vegetated and every plant bore its proper quota. The fields were so even in yield (growth) that little or no difference could be seen in the different parts."

As to the effect on trees, Mr. Yoemans says in his prize report in 1852, "Some of the land I first drained had been planted with young orchard trees and in the wettest places some trees died the first winter, and a greater number the second winter; and some young nursery trees on the same ground were nearly thrown out of the ground by the frost. After draining it, I replaced the orchard trees and all have grown well and the first crop of nursery trees, which I was compelled to remove to save them before draining, have been replaced by others since draining and they have succeeded perfectly so that I may now well say that if we desire to deprive Jack Frost of his power to do harm, we should keep everything within his reach as dry as possible." These statements are made with reference to the hills of Miami stony loam soil in Wayne county.

(9) *Drainage reduces or prevents erosion.* Erosion is the washing of the soil as the drainage water flows down the slope. A saturated soil is in the right condition for erosion to be most serious. On the other hand, thorough drainage permits part of this excess to be drawn off beneath the surface in channels provided for it and which are not subject to such injury. Further, on clay soil where the injury is liable to be the result of the water flowing away because it cannot readily penetrate the surface soil, this effect is reduced by the changes in the physical condition of the soil resulting from drainage — as mentioned above — so that much more of the rainfall is absorbed and thereby retained for the use of plants.

(10) *Drainage increases the yield of crops.* This is, of course, the obvious purpose of drainage as applied to agriculture. It is one of the two fundamental purposes of drainage, the other being increased health-

fulness. The increase varies with the original condition of the land. On acknowledged swamp land, such as is included in the first group of drainage conditions, the difference is that between no crop at all and a large crop. For it must be kept in mind in connection with wet land that its productiveness after drainage is, as a rule, directly proportional to its wetness before drainage. So that the drained swamps are usually the most productive soils for many kinds of crops. And very often these are special crops of large market value, such as celery, onions, cabbage, and some other truck crops not to mention many general farm crops.

Of such lands, which have been drained and which have yielded largely, the Miami black clay loam of the north central states — one of the best corn soils found anywhere — is a notable example. And all of the members of the Clyde series of soils found around the Great Lakes, which are characterized first by their naturally poor drainage and which under cultivation are highly productive, are another pertinent example. But important as are the increased crops from these purely swamp lands, the increased crops under the second and third groups of drainage conditions — the land already included in cultivated fields — are of greater importance to the average farmer. When it is known that the crop returns from such land can be increased from 10 per cent to 100, or even 200 per cent in exceptional cases, without any corresponding increase in other expenses, the matter assumes a practical form. On clay and black loam soil, a man in southern Oswego county writes of the effect of tile drainage that instead of the poorest crops they were the best on the drained part of the field. From southern Monroe county on clay soil it is reported that, "Except in an extremely wet season it is possible to secure a crop of anything planted."

On the rolling upland soils the reports of greatly increased yields are equally as abundant and striking as on the clay soil. Mr. Johnston reports that his yields of wheat increased from the indifferent amount of 15 or 20 bushels per acre to an average of from 30 or 35 bushels with an occasional yield between 40 and 50 bushels. Nor have these yields been temporary for on the same farm now after a lapse of 50 years, similarly large yields are reported. Figure 191 shows a wheat stubble—part of a field of several acres — which is reported to have yielded 44 bushels of wheat in 1907. The stubble is uniformly heavy over this field. On the Miami stony loam in northern Tompkins county a man who has been practicing tile drainage for ten years reports the increased yield to be always 50 per cent and in many cases 100 per cent. On a similar stony loam soil in Niagara county the effects are termed "good." On rolling slatey loam soil in Herkimer county the effects of tile drainage are "very good" crops. On rolling land of a heavy loam character in Monroe

county, the increased yield of the first crop is said to have paid the expense of the improvement, and from the more hilly sections in the southern part of the State the yields of all crops are reported to be greatly increased in every case. This unanimity of the statements of the effect of drainage on the crop yields bears in upon one's mind the conviction of its desirability and profitableness. Drainage, wisely applied and well executed, accomplishes its purpose which is to permit the production of much larger crops.

IV. THE PRACTICE OF UNDER-DRAINING.

No exact directions of general application can be given for the practice of drainage. There are so many variable factors that each proposition must be managed individually with reference to these variable conditions. Soils differ in their texture which, in turn, affects the percolation of water; soils of the same texture differ materially in structure or compactness; they also differ in these points not only from place to place on the same farm or in the same county, but also from surface to subsoil. In some cases the soil is a uniform clay to a depth of many feet, in other places it is a uniform sand or sandy loam of similar depth. In still other places the soil may be made up of alternate layers of these two materials,—sand and clay. The layers may be thick or thin, they may be arranged with either the sand or the clay at the surface; the layers may be continuous or discontinuous. The variation of any of these conditions will modify the character of the drainage system which will give the most effective results.

In addition to the variations just mentioned, and which refer to the character of the soil, are the variations in slope or fall, in area of land to be drained, in the rainfall,—its amount and distribution—in the accumulation of surface drainage water, in subsurface drainage or seepage, commonly called springs, in the prevalence of flooding or overflow of adjacent streams and in the severity of the winter temperatures which will determine the depth to which the soil freezes. All these factors must be taken into consideration in planning and executing the drainage system. It is because of these variables that no single rule can be uniformly applied to such details as depth, size of tile and frequency or arrangement of the drains.

General principles only may be laid down and attention may be called to some of the difficulties likely to arise in order that their occurrence may be avoided. The first broad principle to be kept in mind is that the excess or gravitational moisture in the soil is to be removed to a sufficient depth and with sufficient rapidity to give the plant reasonable root area and freedom from stagnant water for more than a day or two at a time. Second, that water moves with much greater facility

through coarse textured soil than through fine textured ones. Third, that natural surface or underground drainage water should be intercepted at the point where it arises. Fourth, that on flat clay soil the trouble is more likely to be in the surface accumulation of water and therefore a matter of removing surface water, while on sandy soil, if it is wet, the subsoil must be drained as well as provision made for surface water, which will be less in amount and more closely related to the subsoil water than on clay soil. Fifth, the tile should be arranged at the depth where the water flows most readily and most largely. Sixth, on heavy clay soil note carefully the presence or absence of an extensive stratum of well drained gravel or sand at a reasonable depth beneath the clay. It is sometimes possible to drain such soil by means of wells or permeable media by which the surface water can reach the porous stratum. Seventh, the size of the tile must be adapted to the area of land drained by the system and the volume of water to be handled, also to the fall of the drains. Eighth, in very fine sands and muck soils, the land should first be permitted to settle somewhat after the removal of the water by open ditches before the tile are laid. In the case of the sand, precautions against its running into the tile must be taken. In muck soil, precautions must be taken against the shrinkage of the muck after drainage, which may throw the tile out of line and destroy the grade.

a. Kinds of systems.

There are two general types of drainage systems. These are:

1st. The natural or irregular system which follows the natural depressions in the surface and seeks only to remove the water from the low places. Probably the greater part of the land needing drainage in this State requires only this type of drainage system. The system shown in Fig. 195 is an example of this type.

2d. The gridiron or regular system by which lines of tile are arranged at uniform distances apart throughout the extent of the land drained. This is necessary only in very uniform soil of uniform physiographic features where the excess of water is widely and somewhat uniformly distributed. The Yoemans system shown in Fig. 193 is an example of this type.

b. Laying out tile drain systems.

On very level land where the fall is small and the outlet questionable, it is always advisable to employ careful leveling instruments and in such cases it is often necessary to employ an experienced engineer to plan the system, to locate the drains, to determine the fall in different parts of the system and to indicate the cuts necessary. Where

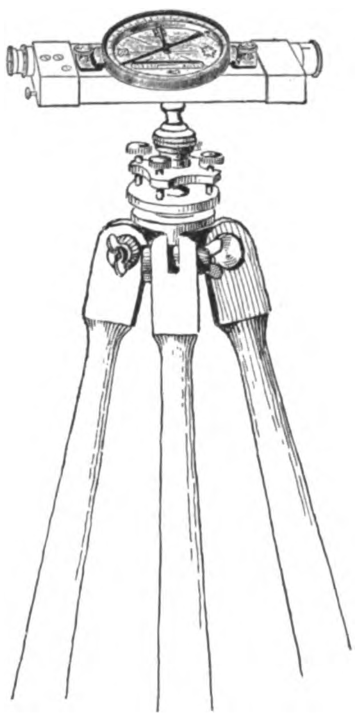


FIG. 196.—*A type of level that may be used in laying out farm drainage systems.*

there is a large body of land in the same neighborhood to be drained, it is advisable that a drainage level similar to the one shown in Fig. 196 be employed on all doubtful propositions. This level costs about $30,00 and the leveling rod shown in Fig. 197 costs $10.00 and these may be purchased by one man or by several men acting in co-operation. A drainage system is such a permanent investment and involves so large an amount of money that no reasonable precautions should be neglected to insure its perfect working. Full directions for the use of such an instrument may be found in books on civil engineering and particularly on land drainage and directions for the manipulating of the instruments are supplied by the manufacturers.

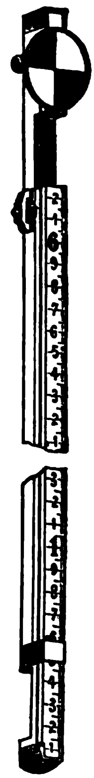


FIG. 197.—*A target rod suitable for use with the level shown in figure* 196.

But in a large number of propositions the fall is so apparent and the outlet so clearly defined and adequate that no leveling instruments of any sort are necessary. In all such cases the general course of the mains and laterals should be staked out in advance of any excavation, beginning at the outlet. If the ditch is to be in a natural depression in which water is likely to flow over the surface even after the installation of the tile, the tile should be placed a little to one side of the bottom of the depression to prevent any possibility of its being washed out. Wherever a lateral joins a main drain or for that matter wherever two drains unite, they should come together at an acute angle instead of at a right angle, with the flow of the water directed with the fall. This arrangement reduces the tendency to check the flow of water in the tile, thereby causing the deposition of material in suspension which might clog the tile. This arrange-

ment is shown in Fig. 198 and in Fig. 199 is shown the use of a rope or cord to secure a good curve for the union of a right angle lateral with the main in making the first cut in the ditch.

FIG. 198.—*Correct form of union of two lines of tile.*

The grade stakes should be set from 12 to 18 inches to one side of the center of the ditch so that they will not be disturbed during the excavation.

(1) *Fall.*—All lines of tile should run with the greatest slope. Even on very rough land the drains should be run directly instead of diagonally down the slope. The fall should be as great as the condition will permit. The greater the fall, the greater will be the carrying capacity of the ditch. It is a rough general rule that doubling the fall increases by one third the carrying capacity of a given size of tile. It is very desirable to have a fall of at least four inches per 100 feet, but drains have operated well with a much less fall — even as small as one inch in 100 feet and under special conditions, where the water flows under a head developed at some other place, tile have been laid on a dead level. Where the fall is less than ten inches per 100 feet, it is desirable to use an instrument in laying out the ditch and if it is less than three inches, the greatest care of an experienced engineer should be employed. Fortunately there are few situations where the available fall is so small as to make such refinement necessary although it is frequently necessary to have the upper end of the ditch much more shallow than the lower end to develop the fall.

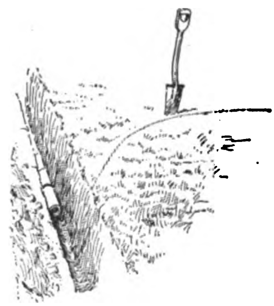


FIG. 199.—*Shows use of cord to form a smooth curve in joining lateral with main ditch.*

In the distribution of the fall where it is necessarily different in different parts of the system, it should be the aim to have the greatest fall nearest the mouth. A lateral drain should never empty into a main drain having a less fall. The most rapid flow will correspond to the greatest fall and particles of soil which would be carried in the lateral would be deposited in the slower flow of the main, permitting it to clog. However, this rule does not oppose the use of a large fall of the last rod or two of the lateral to bring it into the main at the same level. Several types of union between laterals and the main are shown in Figs. 200, 201 and 202. The latter illustrates the best and probably the most used type. A few stones may be placed around the joint to check any tendency to the entrance of soil, which

may result from loose fitting. It is to be noted in this last named union that the lateral joins the main at the horizontal center of the tile and not in a way to have the bottoms of the tiles on the same level.

(2) *Depth.*— The depth of the tile will vary with the character of the soil and the nature of the slope. In very sandy or other porous soil, they may very wisely be placed at a depth of 3½ to 4½ feet. In heavy clay soil they should generally be placed much more shallow and where they are to supplant the surface drains and have to deal primarily with surface water, they may be even less than two feet in depth. The most common depth is 2½ feet.

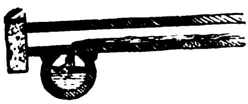


FIG. 200.—*A method of joining lateral to the main line of tile.*

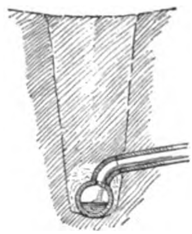


FIG. 201.—*Another method of connecting a lateral with the main line of tile.*

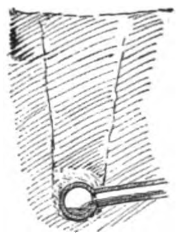


FIG. 202.—*The most common method of joining a lateral to a main line of tile.*

Three limiting factors of shallow drains may be mentioned. These are first, the effect of frost. The action of frost to throw tile out of line is much less than is generally supposed and if the drainage of the soil is thorough, very little or no injury to the system may be expected even if the tile are placed as shallow as 15 or 18 inches. It should be clearly understood that the placing of drains so shallow as this is not advocated on any but level heavy clay soil. The effect of the drainage is to greatly reduce not only the extent of absolute heaving, but also the tendency to freeze. If the tile are within the range of much frost action, only hard burned tile should be used. Second, the interference of tillage implements, such as the plow and subsoil plow. Third, plant roots may sometimes enter and fill up tile drains. This is true not alone of shallow drains; deep drains are also clogged by tree roots and the roots of some crops. This difficulty is due less to the depth of the tile than to the character of the flow of the water in the tile. Roots seek an adequate supply of moisture. If the tile carries only the excess of water during wet priods there will be very little

tendency for the roots to enter the tile. But if the tile carries water from a spring which flows in dry weather, this flow of moisture will keep the adjacent soil in a moist condition which will attract the roots and may lead to their developing into the tiles. In such cases, it may be desirable to cement the joints of the tile in the neighborhood of trees.

FIG. 203.—*A neglected outlet in bad condition as a result of caving of the bank. Probably accelerated by tramping of stock.*

(3) *Outlets.*—The outlet of a tile drain should be clear and unobstructed. Figs. 203 and 204 show examples of bad outlets. In the first case the caving of the bank and perhaps the tramping of stock displaces the tile and they become filled with soil thereby becoming ineffective. In the second case the outlet is drowned, that is, the mouth of the tile is below the level of the water surface in the open channel. This permits the accumulation of sediment in the last few lengths of tile. It also renders the last few rods ineffective as drainage because the water backs up in the tile until the tile is above the level of the water surface. If the fall is only a few inches per hundred feet, this may render useless as many hundred feet of the drain. The water should have a free flow from the mouth of the tile. A well constructed mouth of a drainage system is shown on title page. It is laid up in stone to prevent the caving of the ditch bank and the end of the tile is screened by means of three or four heavy wires or rods set in a wooden frame which fits over the end of the tile. Its purpose is to prevent the entrance of small animals which may enter and get lodged in the tile, obstructing the flow of water. Under all conditions the last rod or two of the drain should be composed of hard conduit. Sewer pipe is sometimes used. A plank box or an iron pipe is also used at the outlet, but the place of both of these may be taken by hard burned or vitrified tile of the ordinary type. However, one advantage of a long plank box or the iron pipe, where the outlet is in a soft bank unsupported by stone work, is that it will be less affected than the tile by the caving of the bank of the open ditch.

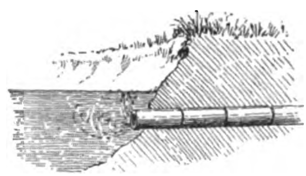


FIG. 204.—*A "drowned" outlet due to level of water being higher than mouth of the tile drain. An undesirable condition.*

If the water has any fall from the mouth of the tile it should strike a stone or cement bottom which is united to the tile. Erosion is likely to occur which may undermine the tile and destroy an otherwise good outlet.

Since special precautions are necessary at every outlet to a tile drain, as few of them should be made as possible. For example, if the general outlet to a series of drains is an open ditch, it is better to have one outlet than several. Instead of leading each line separately to the open ditch, they may be joined to a main tile drain which, in turn, empties into the open ditch at the lowest point. If the main drain is parallel to the open ditch and at a distance from it equal to the distance apart of the laterals, there will be no increase in amount of excavation or length of tile required. The only difference will be the larger size of tile required by the main. This is set against the advantage of one outlet as compared with several outlets.

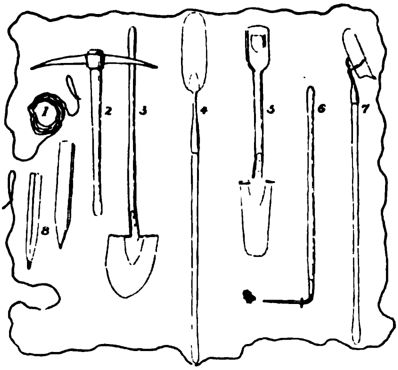


FIG. 205.—*Hand implements used in constructing tile drains.*

c. Digging the ditch.

(1) *Hand tools.*— The tools and equipment needed for digging a ditch by hand are shown in Fig. 205. Some men open the ditch with a plow, but this is usually considered bad practice because it leaves the top ragged and interferes with subsequent excavations. The use of the ditching plow is reported by several men to be satisfactory. It is very convenient for loosening the soil in the bottom of the ditch and hastens the process of removing the earth with a shovel. The narrow spade—No. 5—is the tool most used in making the main excavation. There is considerable facility and ease to be learned in this operation.

FIG. 206.— *Digging a main ditch by hand in stony soil.*

The long handled shovel—No. 3—is used in throwing out loose earth and the pick—No. 2—in loosening hard strata and removing boulders. Grading scoops are shown at Nos. 4 and 7. Number 1 is the grade line for which purpose one of the best is the plumb line cord used by carpenters and masons. Number 8 shows good types of grade and level stakes (Fig. 205).

(2) *Ditching machine.*—On large projects where the soil is not excessively stony the ditching machine, a type of which is shown in Fig.

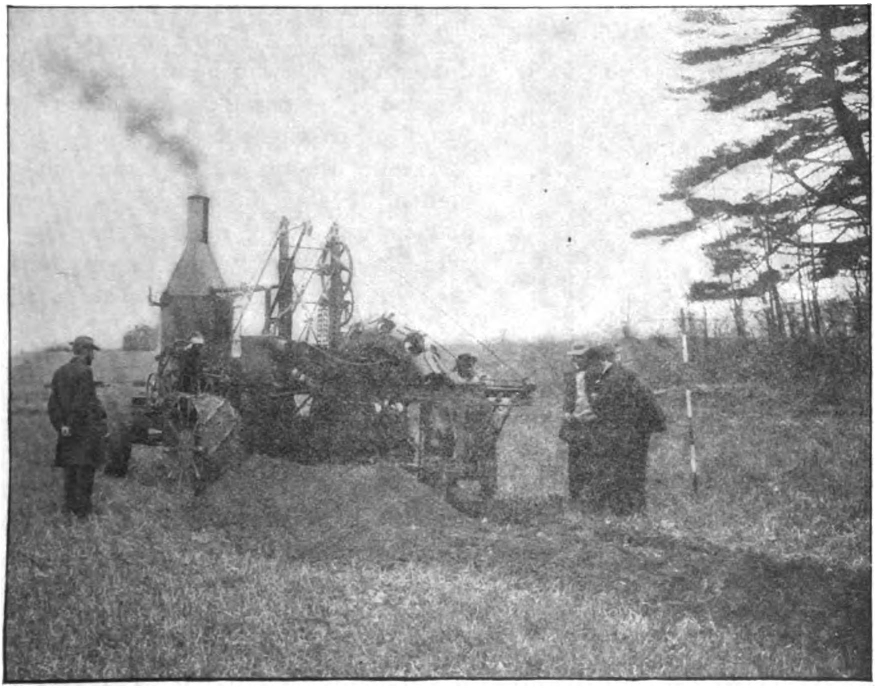


FIG. 207.—*A traction ditching machine in operation on clay loam soil at the New York State College of Agriculture.*

207, may be used to good advantage. There are very few farms which have enough drainage to warrant the purchase of so expensive a machine, but if there is a large amount of ditching to be done in the neighborhood, it may be profitable to purchase such a machine for either co-operative use or for job contract work. Under fairly favorable conditions the excavation may be made as cheap, if not more cheaply, by the use of the machine than by employing hand labor and where hand labor is scarce the former may be the most satisfactory arrangement. The machine shown in Fig. 207 has been used on the University farm during the fall of

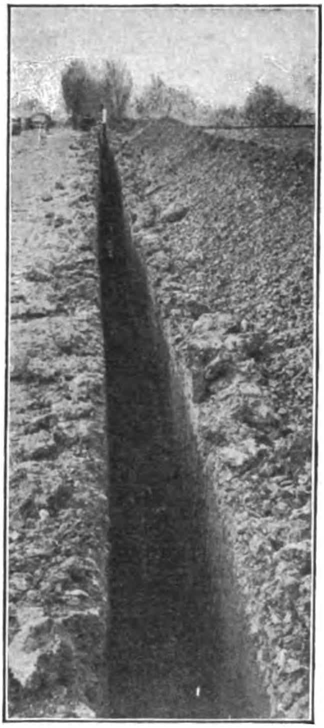


FIG. 208.—*A four foot ditch cut in heavy clay soil on the University farm by the steam ditching machine shown in figure 207.*

1907 and the character of the ditch cut by it in fairly heavy clay soil containing occasional boulders as large as one's head is shown in Fig. 208. This ditch is four feet deep and was cut at the rate of about three feet per minute when the machine was in operation.

A stretch of 17½ rods, three feet deep, was dug in clay soil in one hour and forty-five minutes or at the rate of 10 rods per hour. Under favorable conditions this rate can be maintained. The expense of operating the machine is from $5.00 to $10.00 per day.

Except where large stones in the bottom of the ditch may occasionally mar its uniformity no hand finishing of grade is necessary where the machine is used. As a rule a better finish is given than could be imparted by hand.

(3) *Grading.*—The finishing of the ditch is the delicate part of the operation and is the final test of a piece of work. The leveling may be ever so carefully done but may be rendered of no avail by lack of care in bringing the ditch bottom to grade. In all hand work, a reliable man should be employed for this operation. The superficial excavation should never be made below the grade line and in fact should not come nearer to it than an inch or two. This permits the use of the grade scoop and the creation of a clean smooth grade on firm soil which is the ideal foundation for laying tile. The establishment of an accurate grade is facilitated by a small flow of water in the bottom of the ditch which will quickly reveal any inequalities. Where this is not available a carefully established grade line accurately followed is the most feasible method. A method of correlating the grade line with the grade of the ditch is shown in Fig. 209. The grade cord is drawn at a definite uniform height above the finished bottom

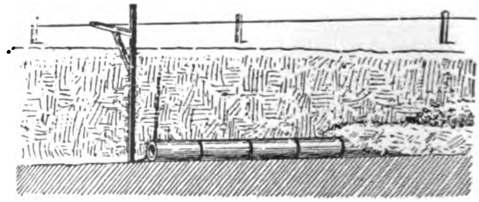


FIG. 209.—*Method of correlating grade of ditch with grade line.*

of the ditch. Another method much preferred to the previous one by many practical men involves the use of "batter boards" instead of grade stakes. These boards are fastened to stakes on either side of the ditch at a sufficient distance — usually a foot or more from the edge of the bank — to insure their security until the completion of the work. These boards are placed across the ditch at intervals of fifty feet or so, near enough so that a cord can be stretched between without any appreciable sag at the middle. The upper edge constitutes the grade line and the grade cord connects these points and gives a reference base directly over the center of the ditch which is an important advantage.

d. Laying and covering the tile.

(1) *Laying tile.*— There are two methods of placing tile in the ditch. The first is by hand. When the tile have been distributed along the bank within easy reach of the man in the ditch, they may be rapidly placed and any shifts necessary to make a tight fit may be quickly made. The ends of the tile are frequently not square and it becomes necessary to turn the tile about to get a tight fit. This may be quickly secured and the tile firmly placed and if necessary, it may be wedged with earth to hold it in place during the filling of the ditch. The second method is the use of the tile hook shown at No. 6 in Fig. 205. It is most convenient in a very deep ditch, but is not so accurate and rapid as the hand method where the former may be used. The open end of the tile should always be closed by a stone or board when it is to be left for any length of time as over night.

(2) *Protecting joints.*— In the early days of the use of tile, it was customary to protect the joints by means of collars or stones. This served two purposes. It aided in keeping the tile in line and also prevented, to some degree, the entrance of soil. But the use of collars has generally been discarded as expensive and unnecessary. If the tile are well made and carefully laid the joints will be sufficiently close to exclude all soils except, perhaps, the very fine sand and silt types. And even these will have but little tendency to enter the tile after the soil has readjusted itself and become granulated. Clay soils, medium and coarse sand and gravel soils and muck give very little, if any, trouble by entering a well laid tile drain. The protection of the tile from the entrance of silt and very fine sand may be effected by placing over the tile a thin layer of three or four inches of coarse sand, fine gravel or vegetable material, such as straw, chaff, leaves or sawdust. The soil may be filled in on top of this as shown in Fig. 210. This material will act as a strainer to exclude the soil from the tile while facilitating the movement of water. The latter material will gradually decay and the soil will slowly adjust itself as the decay progresses without harm to the tile drain.

(3) *Filling ditch.*—As soon as the tile have been placed, they should be covered lightly with earth to hold them in position during the sub-

sequent operation of filling the ditch. After any straw, etc., that may be used is in place, the soil should be carefully thrown in by hand, avoiding the dropping of stone on the tile with such force as to break them. After enough soil has been thrown in and tramped to hold the tile in place, the subsequent filling requires less care and may be performed in a variety of ways according to circumstances. One method is the use of the plow to which the horses are attached by means of a double tree 9 or 10 feet long which permits them to walk in the clear on either side of the excavation (Fig. 211). Another method is a form of broad scraper to which one or two horses are attached. The scraper is placed behind the excavated earth and the horse stepped-up until the earth is dumped into the ditch when the horse is backed up to repeat the operation. When the horse becomes trained to the operation, the process is a rapid one. Another rapid and convenient method of filling the ditch after the first covering of soil is in place is used by H. E. Cook of Denmark, New York. This is an ordinary wheel scraper or road machine similar to that shown in Fig. 216. The scraper is set well to one side and is a rapid method of filling where the machine and teams are available.

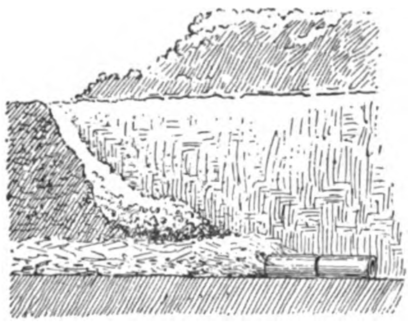


FIG. 210.—*Filling the ditch. Shows use of straw chaff or fine gravel immediately upon the tile to prevent entrance of very fine sand and silt.*

(4) *Sinks and silt basins.* Where it is necessary to admit a large amount of water into the tile rapidly, some more porous medium than the soil must be used and it must exclude the entrance of soil to some extent at least. That is, it must have some filtering capacity. The sink and filter idea is usually combined. One of the most common method used to admit water quickly to the tile is the stone sink. Stone and boulders of different sizes are filled in directly over the tile and up as near to the surface as is necessary to meet the conditions. In very heavy clay where it is undesirable to interfere with tillage, he stone may only rise to the plow line. Under other conditions

FIG. 211.—*Shows use of the plow in connection with a long double-tree to complete the filling of ditch.*

they may rise to the surface. If the volume of water to be handled is very large, the length of the filter may be increased or what is less desirable, the tile may be separated a small fraction of an inch to permit the more ready entrance of the water. Types of stone sinks are shown in Figs. 212 and 213 and in the latter is shown a modified form in which a wooden box with parts of the sides closed by wire screen. This screen box is sometimes combined with the silt basin. The silt basin is a well in which the coarse soil particles may settle while the water is drawn off at a higher level where it holds only the material which may be carried. In this case the silt well is constructed in the course of the ditch and one or more lengths of tile are removed. This same construction of the silt well is used where it is necessary to join several laterals at one point with a main ditch which has a different grade. The bottom of the well may extend several feet below the level of the tiles and any heavy material will fall to the bottom where it may be easily removed instead of being collected in the tile where it may cause damage.

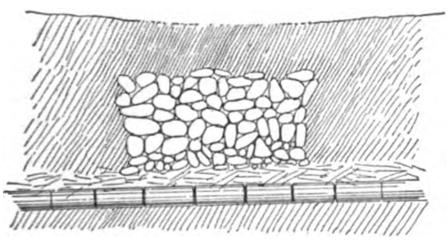


FIG. 212.—*Buried stone filter and sink to facilitate entrance of surface water into tile.*

The clogging of tile by sediment is serious only in drains having a relatively small fall — say less than six inches per 100 feet. Where the fall is greater than this amount, there is a very decided scouring action of the water which will handle any material which may enter a fairly well-made joint.

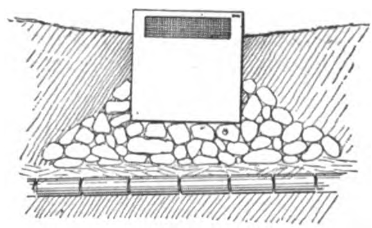


FIG. 213.—*Stone sink and filter with screened box intake.*

(*e*) *Size of tile.*

The proper size of the tile is one of those details for which no explicit directions can be given. Since the cost of tile increases very rapidly with increased size, as small tile as will meet the conditions should be used. But no risk should be taken of using too small tile. The increased cost of the larger sized tile is small compared with the total cost of constructing tile drains and too small tiles at the outlet may render a whole system relatively ineffective.

On the other hand, it is undesirable to use too small tile. Where the fall is less than one-half foot per 100 feet, no tiles smaller than 3 inch should be used. With small tile a relatively small discrepancy in grade may throw the whole line of tile out of commission while with a larger

tile the same error in grade will cause very little harm. The size of the tile to be used depends upon the length of the line. As a general rule, there is a limit to the length of tile of any common size, which should not be exceeded. These limits are also determined by the grade. The relation of these factors is shown by the following table given by Elliott in "Engineering for Land Drainage" (p. 142).

Limit of size of tile to grade and length.

Size of tile in inches	Minimum grade per 100 ft. in feet	Limit of length in feet
2	.10	600
3	.09	800
4	.05	1600
5	.05	2000
6	.05	2500
7	.05	2800
8	.05	3000
9	.05	3500
10	.04	4000
11	.04	4500
12	.04	5300

These limits are based upon perfectly laid tile which is seldom achieved.

Elliott in Farmers' Bulletin 187 on the Drainage of Farm Lands, gives the following summary of the conditions which determine the size of the drains, particularly the mains.

(1) The depth of water to be removed in twenty-four hours over the area of the drainage system.

(2) Rapidity with which the water is brought to the main, that is, the number, size and fall of the laterals.

(3) The existence of emergency surface drainage.

(4) The texture and physical condition of the soil, that is, whether it is open and porous or dense and retentive.

(5) The grade of the ditch.

Ordinarily it is not possible to calculate the size of tile necessary to be used with the same accuracy that a water conduit in a supply system may be calculated. The character of the soil is the first factor which renders such accuracy impossible. It has a great capacity to retain moisture and in a clay loam soil the surface foot may retain, two inches or more of water without becoming too wet. So that the thoroughness of drainage is not determined directly by the rainfall. However, since the farmer must in some way gauge the size of tile used to the area of land drained and the amount of water handled, the following abridged table from Elliott, as quoted above, may be of use.

Number of acres from which ¼ inch of water will be removed in 24 hours by outlet tile drains of different diameters and different lengths with different grades.

Diameter of Tile in Inches	Grade in Inches Per 100 Feet: 1		2		3		6		9	
Length of Drain in Feet	1000	2000	1000	2000	1000	2000	1000	2000	1000	2000
	Acres of Land Drained by Different Sizes of Tile									
5	19.1	15.7	22.1	19.4	25.1	22.7	32.0	30.3	37.7	36.3
6	29.9	24.8	34.8	30.5	39.6	35.9	30.5	47.8	59.4	57.3
7	44.1	36.4	31.1	44.8	58.0	52.8	74.0	70.1	87.1	84.1
8	61.4	50.7	71.2	62.6	80.9	73.6	103.3	98.0	121.4	117.3
9	82.2	68.1	95.3	83.8	108.4	89.6	138.1	131.3	162.6	157.1
10	106.7	88.5	123.9	108.9	140.6	128.1	179.2	170.5	211.1	204.4
12	167.7	139.3	194.6	171.6	221.1	201.8	281.8	268.6	331.8	321.7
14	245.3	204.3	284.9	251.7	323.5	296.1	412.9	393.9	485.8	472.1
16	341.4	284.6	369.3	350.4	449.9	412.2	573.7	548.8	675.2	657.3
18	456.4	381.3	529.1	470.1	601.8	552.5	767.4	733.1	902.3	880.5
20	591.5	245.9	686.3	610.5	780.0	718.2	994.5	954.6	1170.0	1144.0

Elliott says further that, "No attempt should be made to make the capacity of the intercepting drains equal the combined capacity of the laterals where a system of thorough drainage is employed. The size of laterals where the soil is open and permits the use of drains 100 or more feet apart should be 4 and 5 inch tile, which in some cases may be diminished to 3 inch at the upper end. For drains at a less distance apart three inch tile may be used for laterals. They are usually required to carry only a small part of their full capacity and relieve the soil of its surplus water. To do this well, however, they should not be quite full at any time unless it be when there is more than ordinary rainfall. They do not work under a pressure head, hence their velocity of flow is as great when running half full as when running full. Water in a drain attains its greatest velocity when three-fourths full and its greatest rate of discharge when nine-tenths full."

f. Distance apart of drains.

Where the conditions are such as to require a regular system of drains at definite intervals, the interval will still depend on the character of the soil. They will be near together in heavy clay soil and farther apart in sandy soil. In general, however, it is not found desirable even on

clay soil to place the drains nearer than 40 feet and they may be relatively farther apart as the soil is more coarse in texture so that in very porous soil they may, in extreme cases, be as much as 300 feet apart.

Every drainage system should begin at the outlet and this should be constructed with reference to the probable area from which it will be expected to carry water. Then in developing the system of laterals, it is wise to select some unit or minimum interval between laterals. The tile may then be put in at this interval, at twice or four times this interval and if in the course of time it is found that the larger interval does not give sufficiently thorough drainage, the interval may be halved or quartered by the installation of additional drains without in any way affecting the system.

The following table shows the number of feet of tile required per acre when placed the specified distances apart.

20 feet apart	2205	feet
25 " "	1760	"
30 " "	1470	"
40 " "	1102	"
50 " "	880	"
100 " "	440	"
150 " "	270	"
200 " "	220	"

g. Kinds of tile.

There are two general types of tile as to hardness. These are first, the soft, red tile, sometimes called brick tile which have not been subjected to great heat in burning. Second, the hard tile designated as vitrified or glazed tile. Between these two types there is every gradation of hardness. Next to the vitrified tile which are very expensive the semi-vitrified tile is most desirable. These have only the first beginning of vitrification but are far superior to the very soft types.

The hard tile have every advantage over the soft tile for agricultural purposes. The soft tile absorb large amounts of water and when they are subjected to even a small amount of freezing they quickly crumble. On the other hand the hard tile absorbs very little water and are no more injured by freezing when wet than any ordinary resistant stone. In fact hard burned tile are equally as durable as good stone. If there is the least danger of the tile freezing, the hard tile should be used and since they can be purchased almost as cheaply as the soft tile, there is every reason for their use. The water does not enter even soft tile through the walls but through the joints so the impervious character of the hard tile is no objection to their use.

Another classification may be made as to their shapes (Fig. 214). The most practicable forms are the round or hexagonal tile because of the ease with which they may be firmly placed on the bottom of the

ditch in laying and the facility with which close joints may be made by revolving the tile. In addition to the round and hexagonal tile there are the single and double sole tile with round opening. The hexagonal tile are to be preferred to the sole tile as to ease in laying. It is generally unwise to use horse-shoe tile. They are easily broken and may be misplaced by the erosion of the water in the bottom of the ditch. Junction tile of different sizes are made by many manufacturers and it is generally wise for persons inexperienced in making good unions with ordinary tile to use these junction pieces.

The farmers of the state should give especial attention to this point of hardness and should use only hard tile, which they are sure will withstand the destructive agencies. They should hold the tile dealers to the standard and insist on the desired stock, and the manufacturers and

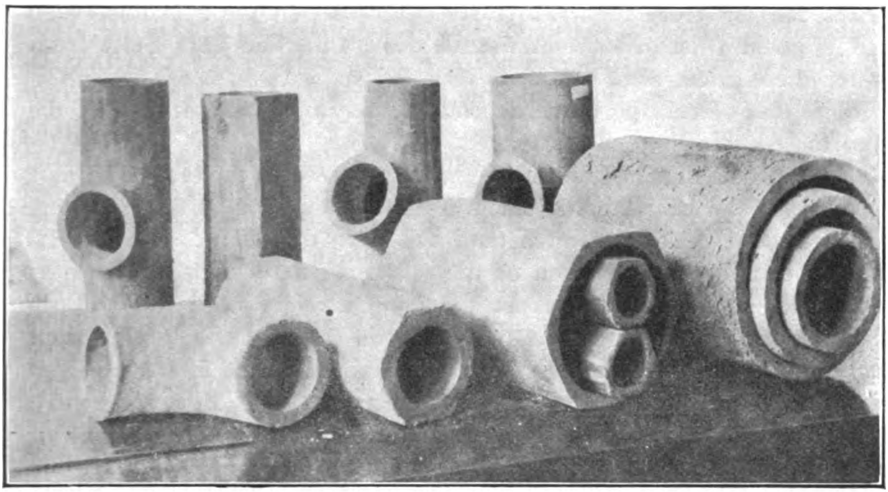


FIG. 214.—*Some types of drain tile.*

dealers on the other hand should take cognizance of this demand and supply the hard burned tile. It is regrettable that so little hard burned drain tile is available from New York dealers and if it is not to be had within the state there should be no hesitancy in going outside of the state where first class tile can be secured. In case of doubt, the farmer should require that a piece of the tile be submitted for inspection before the order is placed and the shipment should be equal to the sample.

(5) *Cost of drainage.*

The cost of draining may be classed under three heads. First, the initial cost of the tile. Second, the cost of transportation from the factory to the farm, including the haul from the railway station and the distribution in the field and, third, the laying out of the system, excavation of the ditch, laying the tile and filling the ditch.

The average list price per one thousand (1000) feet of the different sizes, quoted by dealers in the state, is shown in the following table.

DIAMETER OF TILE	Price per 1000 feet	DIAMETER OF TILE.	Price per 1000 feet
2 inches	$13 50	6 inches	$62 00
2½ inches	16 50	8 inches	95 00
3 inches	21 00	10 inches	165 00
4 inches	34 00	12 inches	230 00
5 inches	44 00		

There is a wide variation in the prices quoted by different concerns for the same size of tile. It is customary to give a discount from these prices ranging from twenty to forty per cent. In the appendix, page 428, is given a list of some of the tile dealers in New York State from whom these prices were obtained.

The cost of transportation depends entirely upon the location of the land to be drained.

The cost of digging the ditch depends on several factors. The first of these is the character of the soil and its topography. Very stony soil is more expensive to ditch than soil free from stone. Second, the cost depends on the condition of the soil particularly with reference to moisture. A moist soil is easier to dig than a dry hard one. Third, the cost of labor is an important element in the final cost. Many men have put in their ditches with labor which could not be effectively used in other directions, but for which they were at expense. More frequently, however, it must be a direct and specific expenditure either for day or month labor or by contract. Figures on cost at one time or place are not necessarily applicable to another place or time, hence any figures given must be taken only as a general guide. For one hundred rods in Seneca county the digging, laying and filling cost thirty-five cents per rod. In Oswego county one hundred and thirty rods cost forty cents — tile buried three feet. In Onondaga county on light clay loam, a two and one-half foot ditch cost thirty-five cents per rod.

The average price reported by a Herkimer county farmer where the draining has been done over a period of years is about seventy cents per rod. From Monroe county on clay soil it is reported to be about fifty cents per rod, ditch three feet deep and one hundred and fifty rods long. On stony loam in Tompkins county, the cost of a ditch from two and one-half to three feet deep is reported as from thirty to thirty-five cents per rod. In the Genesee Valley on a heavy clay loam one hundred acres of land was drained during the season of 1907 at an average contract price for digging the ditch, laying the tile and filling the ditch of from thirty-five to forty cents per rod, but the man employed

was a rapid and experienced ditcher and was able to complete about ten rods per day under average conditions and a two and one-half to three foot ditch. The operator of a steam ditching machine reports that he contracts to dig a two and one-half foot ditch in average soil for twenty-five cents per rod and that an additional one cent per rod is charged for each additional inch of depth. For laying the tile and filling the ditch five to ten cents per rod may be added, making the cost range from thirty to thirty-five cents per rod for a two and one-half foot ditch and from forty-two to forty-eight cents for a three and one-half foot ditch. At the New Hampshire Experiment Station in 1904 on heavy clay soil, the average cost per rod on a system of two hundred and sixty-six rods, for laying out and digging the ditch, laying the tile and filling the ditch, most of which was done by hand, was thirty-eight cents per rod. This represents a little less than one-half of the cost per rod of completing the ditch the remainder being comprised in the cost of tile and transportation. The cost of digging is considered to be unusually high because of the very dry and hard condition of the soil and the employment of unskilled workmen.

Thus far consideration has been given to the cost per rod of installing tile drains. Another view which may be taken is the average cost per acre for tile drains. Obviously this depends on the number of rods of tile put in per acre of land drained. The point has been made that *a large part of the land in the state does not require a regular system of drains at frequent intervals to give large and profitable returns* from the practice. In fact most of the land to be drained would be greatly benefited by the installation of from six to twenty rods per acre strategically placed. That is, the use of tile drains in the low places and springy areas. On this point the investigations of the Wisconsin Experiment Station as reported in Bulletin No. 146 throw much light. A systematic survey was made of the drainage conditions in several drainage districts. It was found that in Mt. Pleasant Township, just west of Racine, where the surface is undulating and the soil is mostly Marshall clay loam and Miami clay loam with small areas of muck and Clyde clay loam, that out of 23,040 acres 13,284 acres are considered to be decidedly in need of drainage and of this area 8,362 acres have been drained at any average cost estimated at seventy-five cents per rod. In this area 60,333 rods of tile were placed or about eight rods per acre, costing approximately $6 per acre. The reports of the farmers in the region showed that the increased value of the land had averaged $20 per acre.

In the Appleton area in the Fox River valley where red clay soil is said to predominate 2,140 acres of land had been drained by the natural system by 19,635, rods of tile or nine and two-tenths rods per acre.

"In order to determine the actual benefits from tiling, a careful estimate was made of the number of acres of corn, barley, oats and hay on

each section of land. The land in each crop was divided into three groups; first, that naturally well drained; second, that having poor natural drainage, but no tile, and third, that having poor natural drainage and tile. A percentage estimate of all crops on each class of land gave as an average on the naturally well drained land 83.7 per cent. of a full crop; on the poorly drained land without tile 64; and on the tile drained land 93 per cent. In order to form a more definite estimate of the benefit of tiling, a comparison was made between the poorly drained and the tile drained lands for each of the four crops, corn, barley, oats and hay. In the case of corn there were forty acres of wet land planted, this gave an estimated yield of twenty baskets per acre. There were seven hundred and fifty acres of the drained land planted to corn which gave an average yield of 102 baskets of ears per acre. In the case of barley, there were 330 acres of wet land planted which gave an average yield of 25.7 bushels and 610 acres of tiled land which gave an average yield of 37.7 bushels per acre. Of oats there were 340 acres on wet land which gave an average yield of 27.6 bushels and 500 acres on tile drained land which gave an average yield of 43.8 bushels per acre. Of hay 1,050 acres of wet land yielded an average of two tons per acre and 280 acres of tile drained land were estimated to give the same average yield."

There is no question but that the same figures or even more favorable ones would apply to many New York districts.

(6) *Permanency of tile drains.*

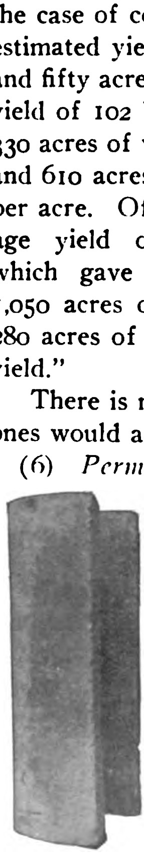


FIG. 215.—*A hard-burned U tile which has served for fifty years at the outlet of one of the ditches on the John Johnston farm near Geneva, N. Y. Still in sound condition.*

The permanency of a tile drainage system depends upon the quality of the tile used, the conditions under which they are placed and the skill with which the tile are laid. Hard tile well placed form practically a permanent improvement. Some of the first tile laid in America are still in operation and are apparently in good condition. The Johnston, the Rose Hill and the Yoemens systems have been in operation for fifty years or more and in the main are in perfect working order to-day. Certainly this is true on the Johnston farm and Fig. 215 shows one of the tile which has been in the system that long. The failure of Mr. Yoemans to leave a plan of his drains together with some neglect has permitted some of the outlets to be clogged, but there is abundant evidence that the greater part of the system is still in good working condition. No other improvement made on the farm is more permanent in character when well executed than tile drainage.

(7) *Stone drains.*

Stone drains have been extensively used in this state in the hill sections. They have been constructed in various ways often with stone which it was desirable to remove from the land. Such drains are effective and have done much good, but the opinion of many reports is that they are unsatisfactory. In the first place they are as expensive if not much more so than tile drains; second, they are not as efficient and, third, they are less permanent. There is a strong probability of various burrowing animals making their home in them and by their operations closing the drains. Many reports are to this effect. It is only where the stone are abundant and at hand and the cost of tile very great that one should feel justified in using stone.

(8) *Open ditches.*

Open surface ditches are very largely used in New York State. As has been said they are used entirely too much and should be largely replaced by tile. But they have a place in drainage work. Where the volume of water to be handled is very large or where the land is so low and flat that it is impossible to construct any other form of drain, they may be used. As carriers of water they are most efficient when their form approximates that of a semi-circle. This usually means in practice that they will have sloping sides, be twice as wide at the top as at the bottom and one-half as deep as the width of the top. To do good work they should be properly graded and kept free from weeds.

Where small open ditches are used, as is sometimes necessary to remove surface water, perhaps to make way for tile drainage when the land has become sufficiently dry, one hindrance to their efficiency is the piling of the excavated earth on the banks of the ditches. This ridge of earth greatly hinders the entrance of water. Also the tramping of cattle tends rapidly to fill up the ditch. Both of these difficulties are obviated by a method of constructing surface ditches used by Samuel Fraser on the Fall Brook Farms in the Genesee valley. He employs the ordinary road machine drawn by four or six horses, according to the character and condition of the soil. The ditches are made very broad with gently sloping sides and the excavated earth is carried back to the crest of the divide between the ditches. Ditches three and one-half feet deep and fifteen feet wide have been made in this way. The width is always proportional to the depth and varies from practically nothing at the head to the maximum dimensions at the mouth. The use of the machine is shown in Fig. 207. Ditches constructed in this way do not interfere with cultural operations and are entirely utilized by the crop. Neither does the tramping of animals destroy their efficiency as readily as the common form of open ditch. At the same time the water finds ready access to the channel.

Summary.

1. A very large amount of drainage is needed in New York State. The conditions needing drainage may be divided into three groups. First, the pronounced swamp lands. Second, the comparatively level land mostly of a heavy clay texture. Third, the rolling upland regions of stony loam soil.

2. Better drainage is needed in order to obtain the maximum efficiency from tillage and manures.

3. Open surface ditches are now most largely used to remove water from wet land. *It is believed that a large part of these open ditches should be replaced by tile drains.*

FIG. 216.—*Use of road machine in the construction of surface ditch.*

4. The first tile drains constructed in America were put in by John Johnston on his farm near Geneva about 1837. His farm of three hundred acres contains between sixty and seventy miles of tile drains practically all of which are still in good condition.

5. Mr. Johnston greatly increased the yield of all crops on his land, which ranges from a heavy clay to a heavy gravelly loam, by the practice of tile drainage. This increased crop return is maintained to the present date.

6. Ten primary effects of drainage may be enumerated. These are, first, it removes excess moisture and firms the soil. Second, it improves the physical condition of the soil. Third, it increases the amount of moisture available to crops. Fourth, it improves the aerotion of the soil. Fifth, drainage raises the average temperature of the soil and keeps it more uniform. Sixth, it increases the available food supply. Seventh, it enables the plant to make better use of the food and moisture in the soil. Eighth, drainage reduces the extent of heaving and other winter injury. Ninth, drainage reduces the extent of erosion. Tenth, drainage increases the yield of crops.

7. On most of the land in the State it is not necessary to install an

extensive drainage system with lines of tile at frequent intervals in order to secure large money returns from the practice. On much of the land a natural system located in the low places will be very satisfactory.

8. The arrangement of drains, the depth and size of tile will vary with the local conditions and must be determined by the man doing the draining, who should keep in mind the essential principles involved.

9. As a general rule on fairly porous soil a depth of from two and one-half to three feet is considered desirable. *But on flat heavy clay soil the tile should be placed much more shallow, even as shallow as fifteen or eighteen inches.* In such cases they are to be considered as subsurface channels for the rapid removal of surface water. The admission of water to the tiles may be facilitated by the use of stone on top of the tile in low places.

10. Wherever there is any chance of the tile freezing only hard burned nonabsorbent tile should be used. Much of the tile manufactured in the state is too soft and porous.

11. The use of instruments in laying out the drainage system is not considered necessary where the fall is one foot or more per hundred feet.

12. Especial care should be used in constructing outlets and as few should be made as possible. They should be protected from the entrance of animal life and from the caving-in and freezing of the bank.

APPENDIX.

I. LAW RELATING TO AGRICULTURAL DRAINAGE.

It is generally recognized that there may be two objects in the drainage of wet land. These are, first, the improvement of healthfulness of the region, and second, economic benefits.

There are two distinct classes of law relating to the drainage of land. These are, first, the common law, which consists of those customs, usages and decisions which have grown up in the country with reference to a particular subject, as drainage; second, the statutory law, which consists of the enactments of legislative bodies with reference to a particular subject and is designed to modify and make the common law more specific.

The common law principle with reference to land drainage is that no man may modify the natural drainage water on his own land in any way which materially affects his neighbor to a disadvantage, unless he can show that it is for the benefit of the public health or welfare. If it is shown to be a matter of public concern, there accrues the right to condemn land for a right of way to provide a suitable drainage outlet. If it is not shown to be a matter of public concern then the owner of a piece of land cannot increase or decrease the total flow of water in any natural drain. He may faciliate the natural movement of water by the use of tile or other artificial means, but cannot materially increase the drainage area of the stream discharged upon his neighbor without being liable for any damages. A drain is recognized to be any course in which the eye of the casual observer is able to see that water will flow naturally at some season of the year.

The statutory law. All of the states have enacted laws regulating the movement and use of natural waters. In 1895, New York passed a general law, which is Chapter 384 of the Laws of that year, providing for the drainage of agricultural lands.

This law has been declared unconstitutional by the New York Court of Appeals, and therefore at the present time agricultural drainage in the state rests essentially on the common law provisions. But since it is so important that there be satisfactory statutory provisions governing this matter, and since the general provisions of the law of 1895 were so excellent, it is deemed expedient to give here a summary of the provisions of that law; and since the objectionable features of the law must be looked for in the decision setting it aside, that decision will be examined together with the rulings and laws in other states, in order to point out, if possible, the lines along which a satisfactory law may be constructed. For the great extent of poorly drained land in New York and the needs of these lands for agricultural purposes render it imperative that proper laws be enacted at an early date, and it is hoped so to set the matter before the people of the state in this publication, as to lead to action in that direction.

It having been found that the State Constitution did not make adequate provision for this type of drainage, the following amendment was made, in 1894, to Section 7, of Article 1, relating to roads and drainage:

> "General laws may be passed permitting the owners or occupants of agricultural lands to construct and maintain for the drainage thereof, necessary drains, ditches and dykes upon the land of others, under proper restrictions and with just compensation; but no special laws shall be enacted for such purposes."

The law of 1895, mentioned above, was based on this amended section, and provided that a person owning agricultural lands within this state may institute proceedings for the drainage of such lands or the protection thereof from overflow, by the construction or maintenance of a drain or dyke, on the land of another person, or the use of mechanical devices, by presenting a verified petition to the County Court of the County, in which such land is located, or if in more than one county, to a special term of the Supreme Court of the district where the lands or a part thereof are situated, setting forth a general description of the lands to be drained or protected, the names and places of residence of the owners of all lands affected by the proceedings, and a prayer for the appointment of three commissioners who shall be disinterested resident freeholders. Due notice of the petition shall be given to all land owners affected. If, as a result of the hearing, the petition appears reasonable and the commissioners are appointed, they shall examine the proposition and determine the following matters:

1. Whether such land shall be drained or protected.
2. Whether it is necessary, in order to drain or protect such land, that a drain be opened through or dykes erected upon lands belonging to another, and whether mechanical devices should be constructed or used.
3. The amount of damage, if any, sustained by such other landowners by reason of the opening of such drain or the construction of such dyke.
4. Take such other and further steps with reference to the proceedings as are provided by this act.

Provision is made for an appeal to the Court by any person aggrieved by the decision of the commissioners; for the preparation of maps and surveys; for the construction of the works under the direction of the commissioners, either by the

owners of the land through which the works pass or by general contract; and in case of inability to agree upon the amount of compensation and damages, for the determination thereof by the commissioners and an assessment upon the lands benefited. The commissioners are to take into account any benefits accrued and may deduct the amount of the benefit from the amount of the damage. The damages and expenses are to be assessed in proportion to the benefits received. Provision is made for appeal to the Court from the decision of the commissioners in reference to the assessment, and in case it is confirmed, provision is made for an application by the commissioners for judgment against any person not having paid the assessment and such judgments shall be docketed and become a lien upon lands, enforceable as provided in such cases by the Code of Civil Procedure. The methods of procedure are prescribed in connection with the various sections.

In the decision in the Court of Appeals (163 N. Y. 133) five of the judges concurred in the opinion that the law is unconstitutional in that it provides for assessment against the owner of land taken by eminent domain. "Strictly construed, the amendment only authorizes laws which will enable an agricultural landowner, desirous of draining his lands, to exercise the right of eminent domain, and thereunder to appropriate another's lands for the purpose, under such restrictions as shall be deemed proper to be made and upon his making due compensation. No right is conferred or implied to assess a portion of the cost and expense upon the other landowners." Judge Gray further held that the amendment to the State Constitution is void, under the Federal Constitution, because since it does not, in terms, declare its object to be a public one, it is construed to refer to agricultural drainage as a private benefit, and the right of eminent domain cannot be invoked in such cases. On the first ground the New York Courts are at variance with the Courts of most other states in the application of the principles of eminent domain, since they have not permitted an assessment to be made against the owner whose lands are taken for a public purpose even though he may derive benefit from the improvement. It is manifestly unfair to oblige the petitioner to bear all the costs of an improvement from which his objecting neighbor may derive large benefit.

The critical point in the second declaration and which was concurred in by only one judge is, that drainage for agricultural purposes in this state is not construed under either the constitution or the decisions and discussions relating thereto, to be a public benefit. Since the amendment thereby fails, the law based upon it must also fail. Drainage for sanitary purposes has been recognized as a public benefit, thereby permitting procedure by right of eminent domain. The concensus of opinion in the state is just coming to the point where it will recognize agricultural drainage as a public benefit, as is done in many states and as is generally true in reference to irrigation in the western states. As is indicated by the decision, the question may be raised whether it was not the intention to so recognize agricultural drainage in the passage of the constitutional amendment and the enactment of the drainage law of 1895. In an opinion dissenting from the last declaration, Judge Haight concurred with Judge Parker in saying that,

> "While I agree with Judge Gray, that the statute under consideration is violative of the State Constitution and therefore concur with him in the result, I am at the same time confident that it was the design of the recent amendment to Section 7 of Article 1 of the Constitution, to authorize legislation providing for a workable scheme by which to secure the drainage of tracts of land, whether large or small, in order to provide for their proper utilization thus establishing it to be a part of the fundamental law of the

State that such drainage constitutes a public use and that such section is not in conflict with the Federal Constitution."

Referring to the public character of drainage for economic purposes, Judge Peckham said (164 U. S. 112, 158):

"The power to drain swamp land does not rest simply upon the ground that the reclamation must be necessarily for the public health. That indeed is one ground for interposition by the State, but not the only one. Statutes authorizing the drainage of swamp lands have frequently been upheld independently of any effect upon the public health, as reasonable regulations for the general advantage of those who are treated for its purpose as owners of a common property."

On general considerations, drainage would seem as much entitled to recognition as a public benefit as is irrigation, provisions for which have repeatedly been made by Federal enactment. The most simple and most effective action would appear to be to insert a clause in the State's Constitution, in connection with the above quoted amendment, recognizing agricultural drainage, in terms, as a public benefit in harmony with other states and the developing spirit in this state. This would be a sufficiently clear expression of public opinion to claim the attention of the courts and perhaps bring them up to the position taken in other states in the application of the principle of eminent domain. If these principles are accepted the law of 1895 would be valid and could be repassed in total as probably the most simple and equitable enactment which can be made.

LIST OF DRAIN TILE DEALERS.

NEW YORK.

FIRM NAME.	TOWN.	COUNTY.
Jackson, John H.	Albany	Albany.
Genoa Brick and Tile Co.	Genoa	Cayuga.
Ryan & Hall.	Cortland	Cortland.
Lyth Tile Co.	Buffalo	Erie.
Peck & Wood	East Bethany	Genesee.
Peirson, Edw. E.	Brooklyn	Kings.
Devendorf, Lanning & Co.	Chittenango	Madison.
New York State Sewer Pipe Co.	Rochester	Monroe.
Rochester Brick and Tile Mfg. Co.	Rochester	Monroe.
Sangerfield Brick and Tile Co.	Sangerfield	Oneida.
Merrick, C. & L.	Syracuse	Onondaga.
Armstrong, F. P.	Warner	Onondaga.
Abby, B. G.	Allens Hill	Ontario.
Hollis, Co., W. M.	Canandaigua	Ontario.
Childs, A. S.	Geneva	Ontario.
Johnson, T. W.	Stanley	Ontario.
Empire State Drain Tile Works	Stillwater	Saratoga.
Cook Brick and Tile Co.	Ithaca	Tompkins.
Lyons Sewer Pipe Wall Plaster Works.	Lyons	Wayne.
Hilfinger Bros.	Fort Edward	Washington.

Akron Vitrified Clay Mfg. Co., Akron, Ohio.

United Clay Companies, 39 Cortlandt St., New York City (Agent for Akron Vitrified Clay Mfg. Co.).

MAY, 1908 BULLETIN 255

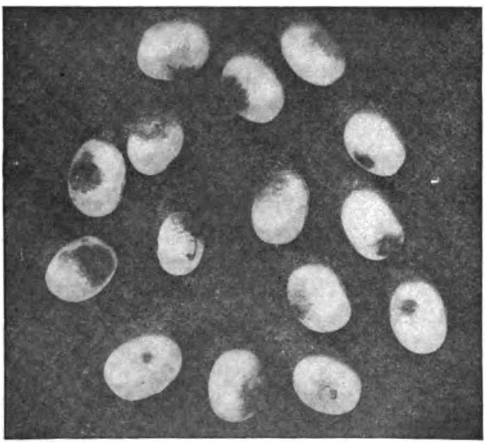
CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

BEAN ANTHRACNOSE



BY H. H. WHETZEL

ITHACA, N. Y.
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FIRST REPORT ON THE BEAN ANTHRACNOSE INVESTIGATIONS.

For the past two years the writer has been devoting considerable time to observations and experiments on the anthracnose or pod-spot of beans. The investigation has now progressed far enough to warrant a preliminary report. Certain recommendations usually made for the control of this disease have been found to be worthless or impractical. Others appear to be of doubtful value. At least one new factor in the control of the disease, viz., clean seed obtained by pod selection, has presented itself and gives promise of solving the problem, A summarizing of the results obtained thus far on these points, seems desirable in order that we may determine definite lines of investigation for our future work, and present to the grower the latest and best information which we have on the subject. The beginning of the work on this disease was marked by the publication of Bulletin 239, "Some Diseases of Beans." It was prepared at the close of the first year's observations on the anthracnose, and is, as indicated therein, largely a compilation from what appeared to be the most reliable sources of information. From a careful and exhaustive study of the literature on the subject up to that time, certain methods of controlling the disease were proposed and recommended to the growers. The bulletin was prepared to meet the demand of growers for information on the subject. Since its publication we have endeavored to determine, largely by observation in the field, whether or not the methods there recommended are effective and practicable.

As a result of three years' observation and experience, together with some experiments directed along the lines of some of the recommendations made, it seems necessary to modify the generally accepted conclusion in regard to the control of this disease. On this account I shall briefly review the different methods proposed in Bulletin 239, pointing out certain incorrect or impractical recommendations.

CRITICISM OF BULLETIN 239.

Seed treatment.—Nothing has been done in an experimental way to determine the accuracy of the conclusions recorded on this point, but for two reasons the writer believes them to be correct: first, *that what experiments have been reported along the line of seed treatment, have in general shown that the benefits derived are insignificant*, especially when

there is taken into consideration the loss of seed resulting from such treatment; in the second place, as pointed out in the bulletin under discussion page 206, "*The mycelium of the fungus is imbedded in the bean itself, and any poison that will penetrate sufficiently to kill the fungus will usually kill the seed.*" In other words, the nature of the bean Anthracnose disease is such that treatment with poisons cannot be effective, since they cannot reach the parasite within the tissues of the host without also destroying the host itself. In the case of oat smut, for example, the spore of the parasitic fungus, which causes the disease, is on the outside of the kernel where it may be readily reached by a poisonous solution. On the other hand, in the case of loose smut of wheat we have a condition analogous to the bean anthracnose. Here the fungus enters the young seed, penetrating deeply into the flesh. It has been found that seed treatment with formalin, for example, which is effective for the oat smut, is entirely ineffective in the case of the loose smut of wheat, and for this reason the analogous case of the bean anthracnose may hardly be expected to be exceptional.

Selection of clean seed.—On page 206, it is recommended that all beans should be carefully handpicked in order to remove the diseased seed. Many growers do this regularly in order to obtain a good stand, for by hand-picking they remove wrinkled and broken seed. It has also been believed that we might thus eradicate the anthracnose. Careful germination tests conducted during the winter of 1907, showed beyond doubt that the anthracnose could not be eradicated in this manner. In the case of White Beans, a certain amount of the anthracnose may undoubtedly be gotten rid of in this way, but even here the writer, though using the utmost care to remove every suspicious looking bean, was unable to remove completely the diseased seed, for upon making germination test of the seed thus sorted, as much as 12 per cent. was found to still show the disease. In the case of black or colored beans, sorting to remove anthracnosed seed was entirely ineffective. One grower who had been to considerable expense in hand picking his beans, which were of the Refugee variety, sent samples to the writer both of the clean beans and the culls. Repeated germination tests from these samples, showed that on the average as many diseased seed had gotten into the presumably clean beans, as had been cast out in the culls. In other words, the grower had thrown away a very large per cent. of his seed, and that too at a considerable expense. From these observations the writer is forced to the conclusion *that the hand-picking of beans to eradicate or even partially control the pod-spot is of no value*, and is therefore not to be recommended.

Removal of diseased seedlings.—In preparing the first bulletin on this subject, the writer found that several investigators of this disease had recommended the removal of diseased seedlings. Theoretically this would undoubtedly be effective, but *it is absolutely impracticable* except in short garden rows, and even then, as the writer has since satisfied himself many times, only an expert would be able to do effective work in removing them. Even if it were possible for the ordinary workman to recognize every diseased seedling, it would be an endless and almost impossible task to go over large fields. Their removal, therefore, may be entirely disregarded as a factor in controlling this disease.

Spraying with Bordeaux mixture.—Several investigators have reported remarkable results from spraying with Bordeaux mixture. After three seasons' observations in large bean fields where the most up to date machinery is used, machinery particularly adapted for the bean crop, the writer is forced to the opinion, that spraying with Bordeaux mixture is, to say the very least, unprofitable. It appears to be not only unprofitable, but entirely ineffective in reducing the anthracnose. In bean fields, side by side, one sprayed and the other unsprayed, grown from the same seed on soil almost identical, anthracnose has been equally destructive. On the other hand, experiments conducted by the writer on a few rows of beans in experimental plots, have apparently shown that if thoroughly and properly applied, Bordeaux mixture is effective in controlling the disease. The difficulty in the field, therefore, seems to be that the present machinery does not effectively cover the parts of the bean plant that must be covered with the poison. If the disease is to be controlled, not only the upper surfaces of the leaves, but the stems and pods must be coated with the Bordeaux. We have been unable to find a machine that will do this, after the beans have formed any considerable top. Until a machine is put on the market that will cover the stems and pods at any stage in the growth of the plant, little or no results can be expected from spraying. It is stated in the bulletin that three sprayings will be sufficient. Some growers have sprayed their beans almost weekly throughout the season, but neither they nor the writer could see any material results from the sprayings. At the bottom of page 208, we find the statement that the writer "has shown that one or two thorough sprayings, even if a large percentage of the plants were badly diseased, will insure a clean and profitable crop." He still stands behind that statement, but would point out, that this was on small experimental rows where the work could be carefully done. That it *may* be possible to control the disease by spraying, even under field conditions, the writer will grant. More than that,

it is proposed to conduct during the next few years careful experiments to determine if an effective machine may not yet be found for this purpose. However, the observations of the past two seasons have brought to light certain conditions, which would still have to be overcome, even if an effective arrangement of nozzles were worked out. In the first place, many beans are grown on extremely stony soil. The difficulty of keeping the nozzles in proper position on such soils is best apparent to those who have tried the operation. Another difficulty is that of applying the mixture at the proper time. This is particularly true during seasons of heavy rain. The growing parts of the plant must constantly be kept covered with the mixture. If the soil is soft from heavy rains, it may be impossible to get on the fields with heavy machinery in time to make the application effective. But even if these conditions were finally surmounted, spraying would still remain very expensive on account of the machinery, chemicals, and labor required, and last and not unimportant, spraying of any kind is an exceedingly unpleasant business, *and can be effectively done only by competent persons.* For this reason, if another method of controlling the disease can be found, it should certainly be tested out and presented to the grower.

Cultivating or working beans when wet should be avoided as much as possible. On this point there can be no dispute. The character of the parasite causing the disease, and the practical experience of growers everywhere show that this recommendation is correct.

Susceptibility of varieties.—The writer has nothing to add to the discussion on this point.

NATURE OF THE DISEASE.

The Bean Anthracnose is known to growers under a number of different names, depending largely upon the locality. Perhaps the most common one applied to this malady is "rust." However, as a matter of fact the disease is not rust at all, though the spots do have a reddish yellow color in their early stages. There is a true rust of beans which is rarely met with in ordinary bean fields. Pod-spot is a name which is frequently applied to the disease, as it appears in the pods. Blight is also commonly used, but incorrectly so, as we have a true bacterial blight of beans, which is not only very common, but frequently quite destructive. The general characters of these three commonest diseases of beans are set forth in bulletin 239, and accompanied with figures, which show clearly their respective characters. This bulletin is still in print and will be sent upon application. Whatever name may be

locally given to the anthracnose, it is still one and the same disease that most bean growers have in mind. The disease is readily recognized by the appearance which it gives to the infected pods, and it is here that the trouble is usually first recognized. Fig. 217 shows the too familiar

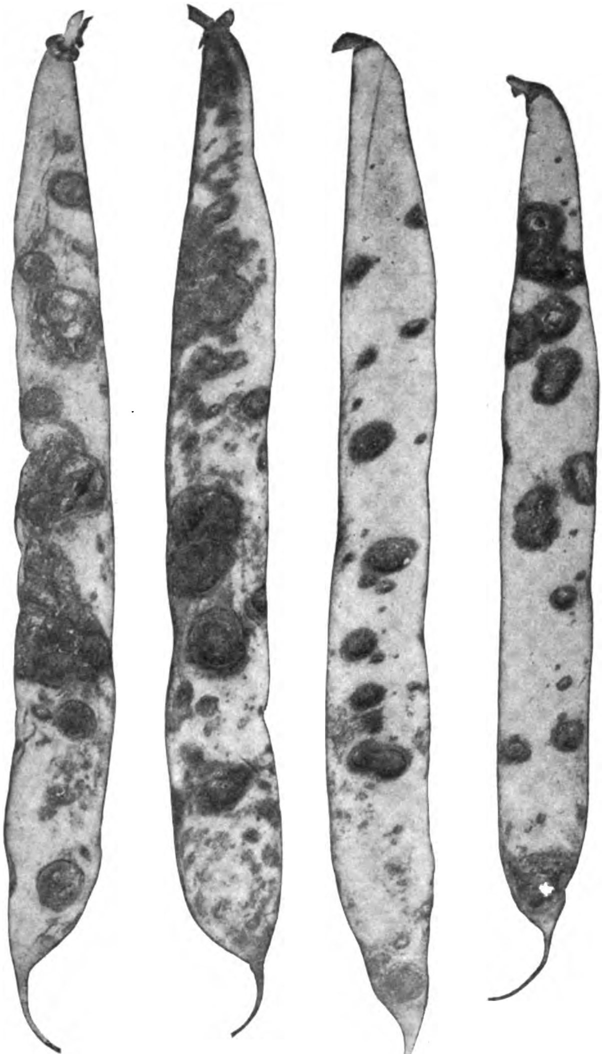

FIG. 217.—*Anthracnose spots or cankers on the pods. The fungus in these cankers penetrates through the pod into the bean.*

appearance of this stage of the disease. The spots or cankers are black with reddish or yellowish margins. Most growers are also familiar with the appearance of the disease on the seed itself, especially on the white beans where it makes rusty red spots of different sizes, sometimes involving nearly the entire seed, though ordinarily only producing a slight discoloration on one side. (Cover.) The disease enters the seed by way of the pod, the fungus penetrating from the outside into the young and tender seed. This is very well shown in Fig. 218. The cankered pod has been carefully dissected away, showing brown spot on the bean just underneath. When the diseased seeds are planted in the soil, and first come through the ground they are sure to show the small black cankers on the cotyledons or seed leaves (Fig. 219) and a little later on the stems. Fig. 220. Growers seldom recognize the disease on the seedlings as that with which they are familiar on the pods and beans. Many of them have observed the blackened stubs of badly diseased seedlings, and have thought the injury due to insects of some kind. Where badly diseased seed is planted the loss from diseased seedlings is at times quite heavy.

FIG. 218.—*Diseased pod dissected, showing the diseased bean within.*

History and economic importance of the disease in this state.—Many growers are inclined to the belief that this is a new disease that became really destructive for the first time during 1906. As a matter of fact, it has long been known in this State and was very well described and figured by Professor Beach of the Geneva Station in Bulletin 48, published in 1892. At that time the disease was so severe in the bean-growing regions of the State as to seriously threaten the industry. Like most other fungous diseases the bean anthracnose has its epidemic periods. Such a period reached maximum severity in the season of 1906. For three or four years previous to this time the writer had observed the gradual increase of this disease in the bean fields which he had occasion to visit about the State. The epidemic period for this disease, as well as for many others, follows very closely the periodic variations of weather conditions. It will be recalled that the season of 1906 was a very rainy one, particularly at the time when the beans were making very rapid growth in the spring, and also at the time when the pods were forming. The three or four years preceding this time had been increasingly rainy during the growing period. The gradual increase of the anthracnose thus followed directly the increasing raininess of the seasons.

Of course the explanation of this is, not that the rainy seasons caused the disease, but that they were especially favorable to the spread and development of the fungus (Colleototrichum lindemuthianum), which is the real cause. As a natural result of this there was an increasingly large amount of infection carried over in each succeeding bean crop, so that the following season always found a larger number of diseased plants in the bean fields. These two factors contributed largely to the epidemic character of the malady which became so marked in 1906. Quite a large number of germination tests were made during the winter of 1907 on the bean seed of the 1906 crop from various parts of this and adjoining states. This seed showed a general average of more than 20 per cent. of anthracnose in it, many samples showing a very much larger proportion than that, while a very few showed as little as 4 per cent. There was every reason to believe that this seed, if planted during the season of 1907 would result in another epidemic of the pod spot. Just the reverse proved to be the case, but this was due, not to the want of the disease in the fields, as I shall point out, but chiefly to one fact, that the season was exceptionally dry, in particular at those times when the fungus was most in need of rain for its development and distribution, namely, during the early stages of germination and growth of the seedlings, and later at the time when the pods were being formed and developed. As a matter of fact, the disease was very common in practically all of the bean fields in the State. Careful examination of a number of fields showed as high as 90 per cent. of the pods spotted with the anthracnose, but owing to the dry weather these spots never developed sufficiently to penetrate the pods to any extent, and thus materially affect the beans within. The bean seed of the crop of 1907, therefore, has been found to be remarkably free from the pod-spot; although in almost any sample a bean will be found here and there that is distinctly spotted. On account of the inadequate greenhouse accommodations during the past winter, we were unable to test out thoroughly samples of the 1907 seed, but

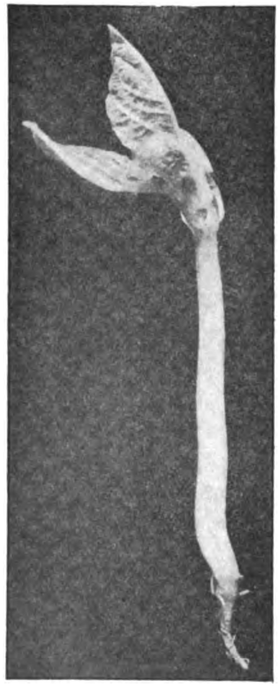

FIG. 219.—*Seedling, just up, showing the disease on the cotyledons.*

from the examinations that the writer has made of this seed, he is inclined to believe that the seed planted this year will be relatively free from the disease, though not sufficiently so to prevent serious loss, should weather conditions be particularly favorable. The practice of purchasing seed from distant seedmen, or from growers in other parts of this State or other States, will be of little or no value in getting rid of the anthracnose, as we have found the disease to be very generally distributed throughout the eastern and central United States and is not unknown, by any means in the West.

FIG. 220.—*Showing anthracnose spots on stem and leaves of bean just before blossoming time. It is from these spots that spores are distributed to the pods.*

Cause of the disease.—As indicated above the disease is caused by the fungus, Colleototrichum lindemuthianum the main features of the life history of which are well known and have been carefully detailed in bulletin 239. Fig. 221, which is reprinted from bulletin 239, shows the general structure of the parasite and the relation which it bears to the spotted seed within. It may be well to repeat here, what has already appeared in bulletin 239 on this phase of the subject. "The disease may and usually does occur, however, on all parts of the plant except the roots. (Fig. 220). It is caused by a fungus known to botanists as *Colleototrichum lindemuthianum* which lives as a parasite in the tissues of the bean. This fungus is a plant, as much a plant as the bean on

which it lives. It has a thread-like mycelium that grows into the tissue of the bean to obtain food for its growth and development and it produces *spores* that serve the purpose of seeds by which it spreads to healthy beans and so reproduces itself. In fighting the anthracnose fungus, we are fighting a parasitic weed, in its habits not greatly unlike the dodder which often destroys alfalfa."

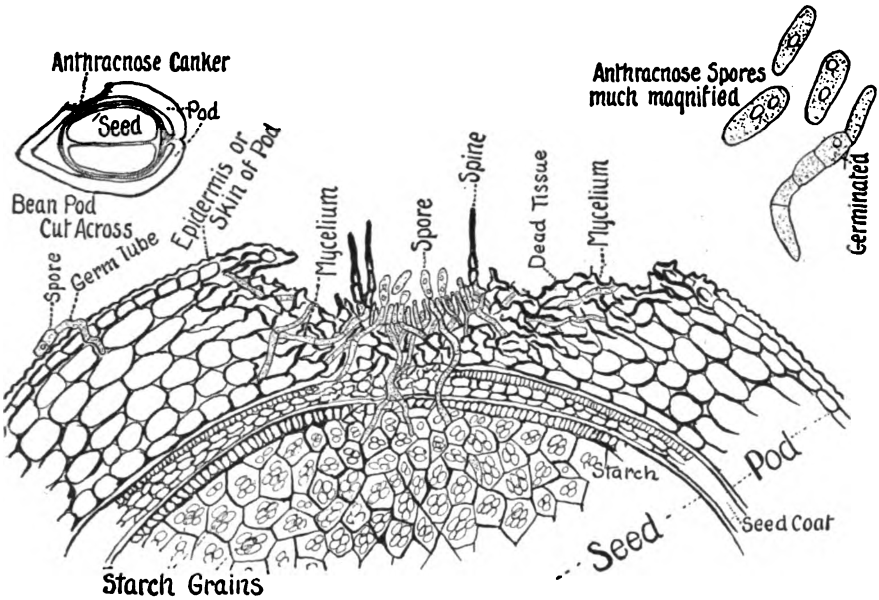

FIG. 221.—*Showing the relation of the anthracnose fungus to the tissues of the bean. To the left above is a diagram of a section across a bean pod through an anthracnose canker. The large drawing below is a much enlarged view of a portion of this same section. It is largely diagrammatic. It shows how the mycelial threads of the fungus may penetrate the seed coat and enter the starchy tissue of the seed, there to remain dormant until the following season. On the left of the large drawing is shown a spore germinating and penetrating the epidermis. This germ tube branches, spreads through the tissues of the pod, and so gives rise to a new spot or canker. To the right above is shown a magnified view of some of the spores of the anthracnose fungus. One has germinated.* (*Original.*)

"The fungus itself is too minute to be seen by the unaided eye. This makes an understanding of its nature and ways of life rather difficult, but the picture of the parasite as shown in Fig. 221 will help to make clear the discussion of the disease. Study the picture carefully before reading the following account."

"It is from the attack of the disease on the pods that the most direct and apparent damage to the crop results. During the time of blossom-

ing and previous, the fungus has been spreading and becoming established on the stems and leaves, and it now attacks the young and succulent pods. With their tender growing tissue full of water and food materials, these pods offer the best conditions for the growth and development of the parasite. Spores from the spots on the leaves and stems fall on the pods, where, in the presence of moisture and the high summer temperature, they germinate, forming a little sprout or germ-tube, which penetrates the tender skin of the pod (Fig. 221) and, branching in the juicy tissues, gives rise to an anthracnose canker. These first appear as little brown or rusty spots which enlarge and darken until nearly or quite black. The dead tissue dries and settles, causing a little pit or sunken place in the pod. In the center of the spot the spores of the fungus are now produced in great abundance. They ooze out and pile up, forming little pink masses easily seen with the naked eye (see Figure 217). These masses of spores are held together by a kind of glue or mucilage which, when dry, sticks them tightly to the spot. When a drop of rain or dew falls on the spot the mucilage is at once dissolved, and the spores are set free in the water. At this time any disturbance of the bean plants will scatter these spores in the flying drops of water. In this way they reach healthy plants near by. This explains why beans should not be cultivated or handled in the early morning while the dew is still on them or directly after a shower. The spores of the anthracnose fungus are scattered only when they are wet. This will also explain why a warm rainy season is so favorable to the development of the fungus. The spores require moisture in which to be distributed and in which to germinate. A relatively high temperature is also most favorable to the disease. The spores are produced in unlimited numbers in the spots on the pod. Fig. 222 shows the spores

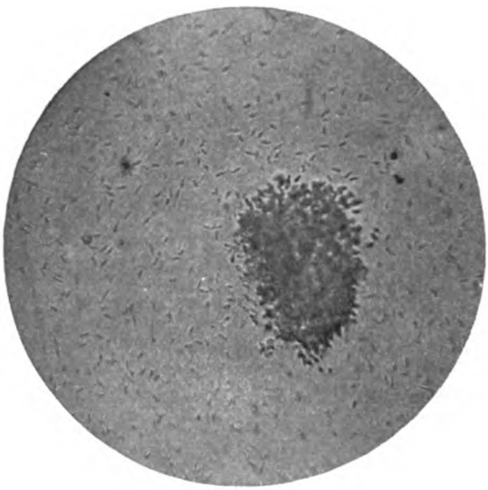

FIG. 222.—*Spore of the anthracnose fungus taken on the point of a needle and placed in a drop of water. Magnified about 55 times. The large blur is a mass of the spores from which others have become detached and scattered about in the water.*

taken on the point of a pin and placed in a drop of water. Only one of these tiny spores is necessary to start a spot. Under favorable conditions these spores spread from pod to pod until practically every bean in a large field may be affected."

CONTROL OF THE DISEASE.

In considering the methods of combatting this disease three or four possible means are presented. First, seed treatment; Second, spraying; Third, the planting of clean seed; Fourth, selection and breeding of resistant or immune varieties.

Seed treatment.—As pointed out above this is of doubtful value, and cannot be recommended, at least not from investigations yet made. If some method of eradicating the disease by treating the seed could be worked out, it would certainly be the most acceptable means of getting rid of so troublesome a fungus. At present, however, the grower cannot afford to spend time and money along this line. It is a problem for the experimentor alone.

Spraying.—This also has been quite fully discussed in the criticism on bulletin 239, and need receive no further consideration here.

Clean seed. Clean seed will grow clean beans.—It is on this proposition that most of the work of our future investigations on this disease will be based. When the writer found that neither the sorting of the seed, nor the spraying of the fields proved effective in practice, he turned his attention to the matter of clean seed. From a very careful study of the fungus that caused the disease, and from observations which he had made in the field, it seemed pretty conclusive that the fungus is carried over from one season to the next, largely, if not entirely in the seed. If then, some method can be found by which perfectly clean seed can be obtained, the problem will be solved. Several experiences have pointed to the conclusion that this would work out in practice. A variety of Black Wax beans were brought by the writer from Indiana in the spring of 1904, and planted in a garden where no beans had been grown, at least for many years. These beans gave a crop perfectly free from the anthracnose and this was more remarkable, since practically all of the beans whether of this or other varieties, grown in neighboring gardens were badly spotted that season. Seed saved from this crop was planted the following season, 1905, in a garden where, the previous season, beans had been badly affected with the pod spot. More than that, they were planted in almost the identical place where the diseased beans had been grown in 1904. Again, they gave a crop perfectly free from the anthracnose, while as before the same variety

grown from seed purchased in the city market gave a diseased crop. The two gardens in which these crops of beans were grown were side by side, separated only by a woven wire fence, the ends of the rows of the beans in the two gardens being not more than 20 feet apart. During the winter of 1905–06, the seed saved from this crop was almost entirely destroyed by weevils, so that for the planting of 1906 there was only a very small quantity of seed, sufficient to plant only a part of a row across the garden. Seed of the same variety, with which to complete the planting, was purchased in the city market, one long row being completed across the garden. Shortly after the beans were up the disease became quite virulent in the plants grown from the purchased seed, while none was to be found in that grown from selected seed of the previous season. All of the plants were thoroughly sprayed once, but the disease had at that time made such progress that it was not controlled, and a gradual spreading of the disease was observed in the row on adjoining plants from clean seed, so that by the time the crop was ready to harvest, only a few of the plants from the clean seed showed pods entirely free from anthracnose. This clearly indicated that the absence of the disease the two preceding years had not been due to varietal resistance. It could be explained only on the basis that there had been no disease in the seed. It further indicated that the disease was not readily carried from one garden to another, else the crop of 1905 should certainly have been diseased. During the winter of 1905–06 a small amount of this seed was sent to a lady near Ithaca, who had been unable to grow Black Wax beans for a number of years, that were free from the pod-spot. She reported a perfectly clean crop in 1906 and saved seed for the following season. At the end of the season, 1907, she again reported a crop entirely free from the spot. It should be pointed out here, that the clean crops of 1906 came in a year when the bean anthracnose was particularly destructive. During the season of 1907, the writer did not plant any seed from the crop of 1906, as what little he succeeded in saving from the uninfected plants, was totally destroyed by weevils during the winter. Fortunately the lady to whom he sent the seed in 1905, sent him during the winter of 1907 a small quantity of this seed, which is presumably free from the anthracnose. This will be planted in 1908, and the writer has every reason to believe that it will give a clean crop.

During the winter of 1906–07, communication was received from a gentleman, in the western part of the United States, who grows beans to a limited extent on irrigated lands. The gentleman declared that he was able to plant diseased seed, received from any of the North East-

ern States, on his irrigated land, and grow a crop perfectly free from the parasite. He accompanied his statement with about a quart of Wardell's Kidney Wax beans, which he had grown on his irrigated lands during the season of 1906. Careful germination tests were made of this seed and no evidence of the anthracnose was to be discovered. The seed was planted during the season of 1907 on an isolated plot of land on the University Farm. At the same time on another plot of land about a quarter of a mile distant was planted seed of the Davis White Wax and Refugee Green Pod, both of which showed by germination test, a large percentage of diseased seed. The Wardell Kidney Wax from the irrigated lands gave a crop entirely free from the anthracnose except for one plant. This plant was at the end of the patch, along which ran a foot path leading directly from a house across the road into the University farm opposite. As there was a garden with diseased beans at the house across the way, it seemed very probable that the infection was carried in by some person passing through this diseased patch and along this pathway. All of the plants in the immediate neighborhood of the infected one were carefully examined, but absolutely no trace of the disease was to be found on any of them. This plant was removed and destroyed. The diseased seed planted in the plot a quarter of a mile away gave a crop that was very generally affected with the anthracnose, and this bear in mind, during the season of 1907, when weather conditions were very unfavorable to the development of the disease. These observations and experiences convince the writer that here is the most promising suggestion for a practical and effective method of controlling the disease. It seems evident, first, that the disease is carried over entirely in the seed; second, that the disease is not ordinarily carried for any considerable distance by natural agents, such as rain, wind, etc.; third, that if perfectly clean seed is planted and ordinary precaution taken to prevent the introduction of the disease on tools, or by workmen, a perfectly clean crop can be produced, even in seasons the most favorable to the development of the fungus.

Methods of obtaining clean seed.—It is first necessary to work out a satisfactory method of obtaining clean seed of the varieties particularly desired in any locality. As has been clearly shown, hand sorting of the seed, after it is has been thrashed from the pods, is a failure, so far as eradicating the anthracnose is concerned. Even if a large percentage of the disease might be eliminated in this way, it would still be ineffective, since in seasons favorable to the disease, a very small percentage of affected seed might be sufficient to destroy or seriously injure the crop.

Considering the manner in which the fungus finds its way into the seed, it seems evident that *if no spots are to be found on the pods, none of the seed within will be diseased.* That is to say, healthy pods contain healthy seed. It is just possible that we may have one exception to this, though, so far as the writer has been able to find there is no positive evidence in favor of such an exception, namely, that infection of the seed may take place by way of the blossom, without any evidence of such infection on the pod or in fact in the seed itself at maturity. Blossom infection is known to take place in a number of fungous diseases, but the nature of this disease is such that, that hardly seems probable. It has been pointed out by some that the sudden and destructive appearance of the disease in pods at a certain stage in their development, seems to indicate that something of this sort takes place. It is a common observation also, that pods picked in the evening apparently entirely free from the disease will sometimes be found the following morning to be very badly spotted, and shippers of garden truck have often suffered serious losses from the development of this disease in snap beans during the short time required for the transportation from fields to market. Nevertheless, while the writer has seen several cases of this nature, he has never been satisfied that the infection was not due to the ordinary inoculation of the pods by spores from occasional diseased pods among the healthy; the rapid development of the disease in such cases being due ordinarily to favorable conditions of temperature and moisture. Surprisingly enough in the cases of this kind of which the writer has known, a relatively low temperature, particularly a sudden drop in the temperature seems to have been the controlling factor. If then, the principle laid down, that healthy pods contain healthy seeds, holds true, it seems that we have a fairly easy means of obtaining clean seed. During the season of 1907 the writer undertook the selection of clean pods of a number of varieties of beans in order to determine whether it would be practical and effective. On account of the large amount of work on hand during the autumn, only a very small amount of seed of a few varieties was thus obtained. Perhaps, enough to plant half an acre of a total of five or six varieties. Some germination tests of the seed thus obtained were made during the winter of 1907–08, and in no case was any anthracnose discovered. This seed has been planted during the season of 1908, to see if it will give a perfectly healthy crop. However, the conditions under which the seed of this year were collected were far from favorable. In the first place, the selection and sorting of the seed had to be left largely to students or inexperienced assistants; in the second place, the season was so far advanced when the selection

of pods was made when most of them were over-ripe and in some cases covered with sand and dirt from heavy rains. The selections should have been made at the time when the pods began to shrivel but before they had become perfectly dry. It was found that hand picking and sorting of these pods was not nearly so difficult a problem as one might expect. The anthracnose cankers are so large and readily recognized, that with a little coaching any person of ordinary intelligence and care may be depended upon to sort out the healthy pods. It was necessary however to examine both sides of every pod.

Our experience with seed grown on irrigated lands is too limited to warrant us in coming to any definite conclusions in regard to it. The philosophy of the matter is that, "since there is no moisture in the air, (as no rain falls at the particular place where this crop is grown) the spores of the fungus cannot be distributed," for as pointed out on page 440, the spores remain glued to the spot on which they are developed until dissolved in a drop of rain or dew. We would naturally infer therefore, that where no rain or dew falls upon the parts of the plants above ground, spores would never find the necessary means for distribution. It is not safe, however, to conclude from the limited experience of the writer that seed from all irrigated lands will be found to be free from the disease. However, such sources are worth consideration, and the writer proposes to again this year plant the clean seed obtained from last years crop of Wardell Kidney Wax, and has already received seed from the same seedman of two varieties of beans of the crop of 1907. These will also be planted and tested out in the same way. The following extract from a letter from Dr. W. A. Orton of the Bureau of Plant Industry, U. S. Department of Agriculture, may be of interest in this connection.

"In regard to the possibility of bringing seed beans from irrigated regions, I would say that during my summer trips I had several opportunities of observing conditions in irrigated districts, and for the first time. I am somewhat surprised to find how prevalent fungous diseases may become in irrigated fields. In a number of instances I found peronosporas, anthracnoses, and similar fungi, prevalent in irrigated fields, where the operations of watering were carried on in such a way as to create a moisture laden atmosphere around the plants, although the general conditions in the locality were, of course, extremely dry. I did not happen upon any bean fields on irrigated lands, but I do not doubt that such fields might be free from anthracnose, as you have found in your experience. I do doubt very much, however, whether it would be safe to rely upon seed from irrigated fields. The Pacific Coast points which I mentioned, are peculiar in that beans are regularly grown from

planting to harvest without a drop of rainfall or irrigation water. Conditions in the West are however extremely variable and each locality must be studied by itself for I found localities like this just mentioned, which were, nevertheless, subject to occasional outbreaks of fungous diseases because they were exposed to continued heavy fogs from the Pacific. This makes an additional reason why general statements in regard to the source of seed would not be reliable."

RESISTANT OR IMMUNE VARIETIES.

Very little work, so far as the writer has been able to discover, has been done along this line, and as pointed out in the criticism on bulletin 239, nothing can be added at the present time to this phase of the subject, It is proposed during the season of 1908 to make a test of as many varieties of beans as can be gotten together to determine what ones may be found more or less resistant to this disease, and perhaps later to carry on in connection with the Plant Breeding Department, some work in breeding resistant varieties. Little immediate relief, however, can be promised from results of such work, since even if resistant varieties are obtained, there will probably be no satisfactory types that can at once be substituted for varieties now generally recognized as most favorable for certain purposes. There would probably be required at best, years of selection to bring them to a condition where they would be of general value.

PLANS OF FUTURE WORK.

A plan of the future work on this problem, may not be out of place in concluding this outline. Briefly, the lines along which the work on this problem are to be prosecuted are as follows: In general the plan comprises, first experiments on the University Farm, carried on under the careful and constant observation of the writer and an assistant, who will be chiefly concerned with this problem for the next three years; second, with cooperative growers about the State, to test in the field the results obtained in an experimental way here at the Station. The chief problems to be solved are:

First, to test the effectiveness of clean pod selection as a means of obtaining clean seed and to demonstrate whether such seed will under all weather conditions grow a clean crop, without spraying or any other treatment for the disease.

Second, to devise and test out a practical method of obtaining sufficient clean seed for planting the crop each year. The latter will be largely cooperative work with the grower.

Third, to determine whether the fungus is carried over winter in the soil, or on tops, pods, etc., and thus to find out whether it will be safe

to follow beans with beans year after year. as is sometimes deemed advisable by growers of snap beans.

Fourth, to determine whether the seed within the pod may be infected by the parasite without showing any external evidence on the pod.

Fifth, to determine whether seed grown on irrigated lands in regions where there is no rain fall, will be found to be constantly free from the disease.

Sixth, to determine the value of spraying in large field operations and to test out the effectiveness of various types of machines devised for this purpose.

Seventh, to determine whether closely related species or strains of the anthracnose fungi occurring on other common hosts, such as apple, grape, watermelon, etc., will cause the disease in beans, and vice versa.

Eighth, to develop strains of resistant or immune varieties by means of selection or hybridization.

Ninth, to determine the value of various methods of seed treatment.

It is the purpose of the Plant Pathologist at this station to make the investigation of this disease of beans, one of the chief lines of work for the next three or more years, until the problem is finally and satisfactorily solved. To this end Mr. M. F. Barrus, recently appointed assistant in this Department, has been detailed to devote a large part of his time to the problem and it is expected that the matter will be thoroughly thrashed out before it is dropped.

The results and recommendations presented in this bulletin are based on experiments and observations covering a relatively short period of time. More extensive experiments covering a period of years will be necessary before definite conclusions can be reached on all the points herein discussed. The writer shall not hesitate to abandon any of the recommendations or suggestions presented if they prove incorrect or impractical. This is simply a record of progress, to clear the ground for the next step in the solution of this problem. So important is it to the grower that he should have early advantage of every possible way of combatting these pests so destructive to his crops, that the writer at this time presents what conclusions and suggestions he has even at the risk of having later to modify or withdraw them. Correspondence on this subject is earnestly requested. It is hoped that considerable seed for cooperative experiments with growers may be obtained this season. We shall be glad to outline plans and give what assistance we can to any one who may desire to obtain clean seed for next year's planting. Address all communications to Department of Plant Pathology, New York State College of Agriculture, Ithaca, N. Y.

H. H. WHETZEL.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION

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129 How to conduct Field Experiments with Fertilizers, 11 pp.
134 Strawberries under Glass.
135 Forage Crops.
136 Chrysanthemums.
137 Agricultural Extension Work, Sketch of its Origin and Progress.
139 Third Report upon Japanese Plums.
140 Second Report upon Potato Culture.
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253 Black-rot of the Grape.
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JUNE, 1908 BULLETIN 256

CORNELL UNIVERSITY

THE COLLEGE OF AGRICULTURE

Department of Rural Art (Extension Work)

STREET TREES

THEIR CARE AND PRESERVATION

By ALBERT D. TAYLOR

ITHACA, N. Y.
PUBLISHED BY THE UNIVERSITY

ORGANIZATION

Of The Cornell University Agricultural Experiment Station.

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CARE AND PRESERVATION OF STREET TREES

Much has been written with reference to the diseases of shade trees and their control, but there seems to be little information bearing on other phases of shade-tree work. This bulletin is intended to be the first of two publications relating to this subject; and while its purpose is to discuss the care and preservation of street trees, no attempt is made to touch on the diseases of trees caused by insects and fungi. The writer's object is to point out, and to show by means of illustrations and discussion, the harm to which our trees are subjected through ignorance and neglect, and to awaken within the minds of public spirited citizens a feeling that may prompt them to join forces in an effort to protect that to which nature has given them a life-lease, but not an undisputed ownership.

The writer is indebted for valuable photographs and suggestions to Mr. J. Horace McFarland, president of the American Civic Association (Figs. 226, 227, 228, 235); The Newark Shade Tree Commission; The East Orange Shade Tree Commission; The Cleveland Park Commission (Fig. 224); Boston Park Commission (Fig. 225), and Mr. John T. Withers, Landscape Gardener and Forester (Figs. 253, 254, 255, 256); and to others.

I. Sources of Injury to Street Trees. (Pages 305–323)

The sources of injury are many and serious, and the average citizen realizes only too keenly that they are increasing. The many dangerous enemies, against the ravages of which shade trees must be protected, are of no trifling importance when considered in their relation to the public welfare. On every side the observer may see numerous evidences of these injuries, which become inexcusable when we learn that the great majority of them can be traced to neglect or ignorance on the part of owners or others.

(1.) *Public utilities.*

Trees are seriously damaged by escaping gas which penetrates the surrounding soil, by electricity which is discharged from the wires that come in contact with them, and by telegraph and telephone linemen who may be encouraged to disregard the value of a tree in order to run a line of wires with the least possible inconvenience. Effectively

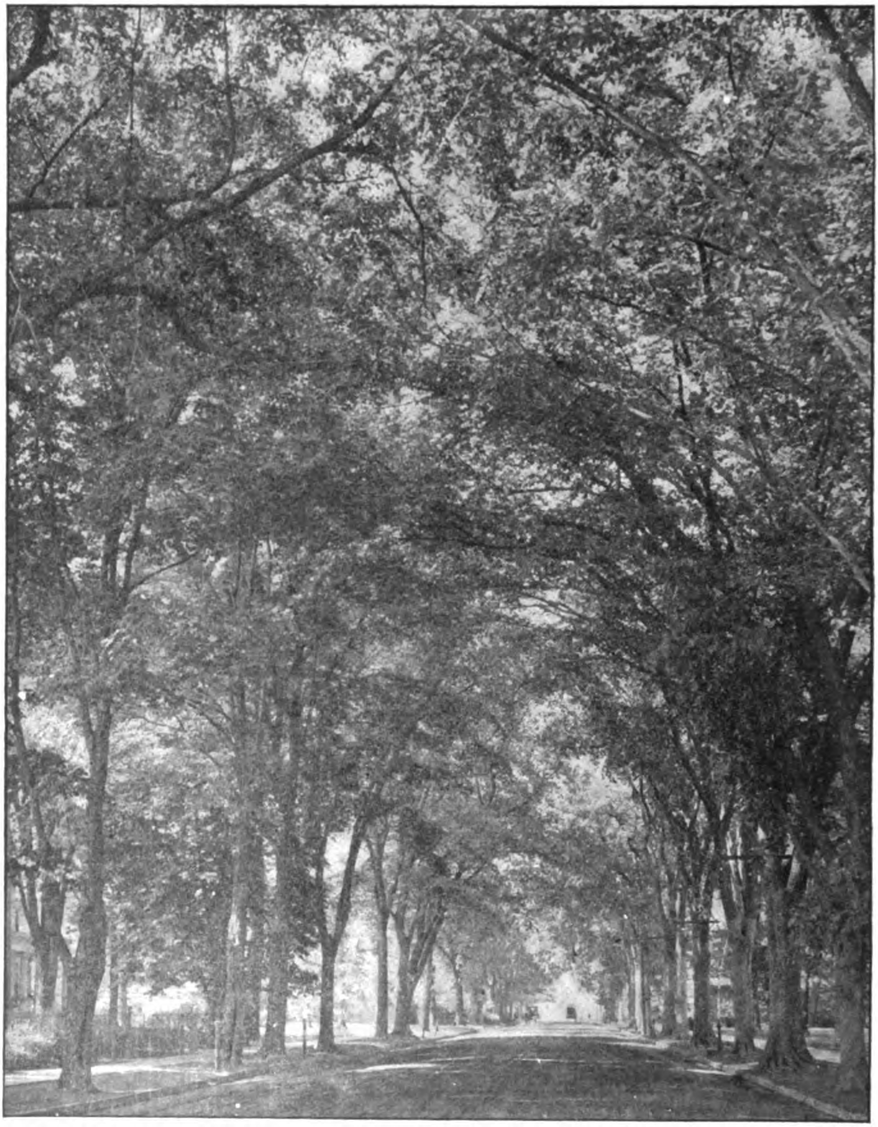

FIG. 223.—*Avenues of this type are valuable assets to towns and cities. Every care should be taken to preserve them. Improvement societies should foster public sentiment to insure their safety.*

to control such dangers means the enforcing of old laws and perhaps the adoption of new ones.

(*a*) *Gas*. The number of trees suffering from the effects of gas appears, from reports, to be increasing. The introduction of larger gas mains to meet the increasing demands of consumers has magnified the opportunity for leakage into the surrounding soil; and this, together with the fact that street surfaces are paved or macadamized, which tends to confine the escaping gas, explains the sickly and unhealthy appearance of thousands of shade trees. Professor G. E. Stone, of the Massachusetts Agricultural College, for a number of years has conducted experiments on the injury to trees by gas escaping into the soil, and he has demonstrated the fact that hundreds of trees in cities and towns are killed each year by this means. The degree to which trees may be injured depends on the quantity of gas coming in contact with the roots. In many localities the volume of escaping gas may be but a few cubic feet each day. The trees affected by small amounts very often show no marked effects the first few months or even years; however, with this continual flow into a soil from which it cannot escape, the time will finally come when the trees will be killed. When large quantities of gas escape each day, the trees whose roots penetrate the soil that is vitiated, will show signs of injury in a few months, and sometimes in a few weeks. An instance of this is cited, in which, in one small city with four miles of laid pipe, there were along the line of the pipe, two years after laying, about one hundred trees that had been injured beyond recovery. Here Professor Stone estimated that three or four hundred additional trees had been so strongly affected by the gas that they were certain to die prematurely.

One of the injuries resulting from escaping gas is the presence of a greater or less amount of dead wood throughout the specimen each year. This condition is frequently seen when the leakage is small, and the ground, being aerated because of its open character or because of the absence of a water-tight layer of road material, does not become sufficiently charged to cause immediate death to the tree. In the case of severe injury to large trees, causing their complete or partial defoliation, there remains little hope of recovery, and their immediate removal is advised.

The detection of trees that are suffering from gas in the soil requires the services of one who has had experience with trees thus affected. The most common indications of gas-poisoning are the yellowing and drying of the leaves during early summer and their subsequent

early falling, the loosening of the bark and its falling away from the trunk, the appearance of fungous growths on the trunk and branches, and the occasional peculiar color and odor of the wood. The best method of treating trees which show the early stages of injury from gas is at once to aerate the soil in the immediate vicinity of the roots by breaking up the hard coating on the surface. The practice of opening a ditch and leaving it open for some time has frequently saved trees.

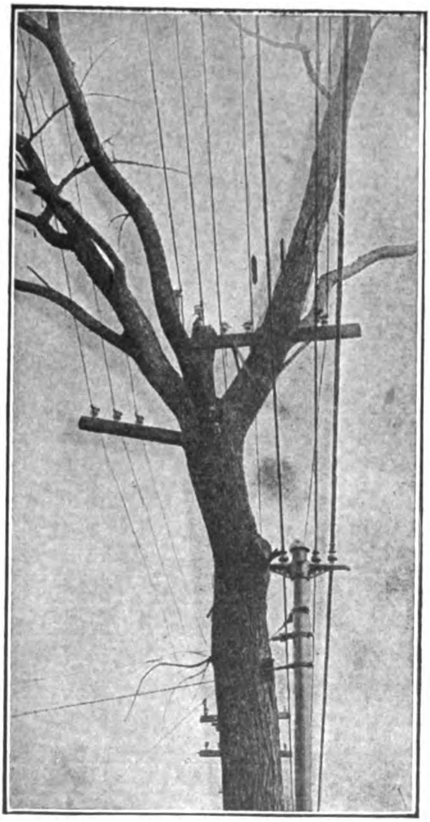

FIG. 224.—*Wires should seldom be attached to trees; the cross-bars injure the bark.*

This injury to street trees from gas has been demonstrated so conclusively that gas companies now recognize the fact, and often settle damages for suits brought against them on this account. Some of the settlements which such companies have made for trees injured or killed in this way have ranged from $5.00 to $150.00 per tree, depending on the location and the valuation of the abutting property. There seems to be but one means of controlling this danger, and that is to cause gas companies to be more careful in the inspection of newly made joints by the imposition of suitable fines for injuries. Public sentiment should control in such work.

(*b*) *Electricity.* The network of electric railroads and electric lighting systems, which serve as a means of more closely uniting our cities and towns, has proved a dangerous enemy to shade-tree life. There is a constantly increasing number of fatal injuries from the contact of live wires with the trees.

The injuries caused to trees from electricity, directly or indirectly, are a source of much complaint. Telephone companies sometimes cut their way through avenues of trees, and the electric light companies often go farther and in many cases burn their way through.

While the instances of the direct killing of trees because of escaping electricity are not so numerous as some would have us believe, yet the damage from this source is important. The wires of these companies, often carrying heavy currents, are generally placed adjacent to, or directly over the lines of avenue plantings. It is during wet weather, when parts of a tree are in contact with live wires, that the greatest damage to the tree arises from this source of injury. The wires used for lighting purposes are considered more dangerous than those of traction companies. This is true, in the first place, because the former are more often likely to be located in the tree belt; and in the second place, the voltage and current are greater. There are many cases cited in which the burning from contact with branches has been such that it necessitated the removal of a leader and thus spoiled the symmetry of the tree. Large numbers of trees on city streets, adjacent to lines of electric wires, are sickly and disfigured. Without further investigation, this condition is sometimes attributed to the effects of electricity, while, as a matter of fact, it can often be traced to other

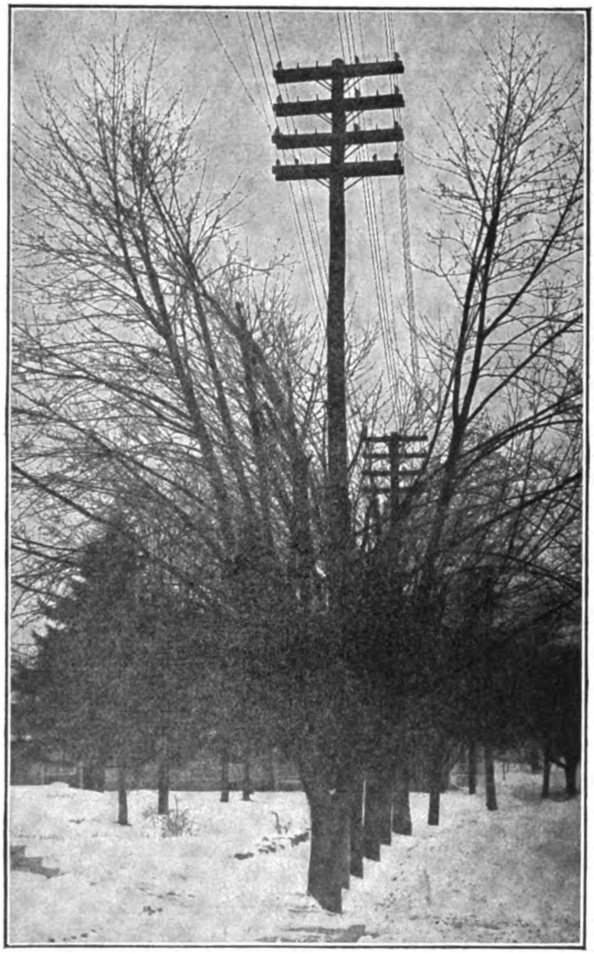

FIG. 225.—*A row of beautiful trees damaged beyond recovery to allow the passage of wires.*

adverse city conditions. Societies should take all precautions necessary to safeguard their trees against any of the possible detrimental influences arising from electricity in any form, and by so doing avoid complaint against companies for injuries to trees for which they really are not responsible.

(*c*) *Injuries incident to the presence of electric and telephone wires.* Aside from the fact that street trees may suffer much damage from the effect of gas on the roots, and from the burning effects of electricity, there is a third and perhaps more important source of injury. This is the wholesale slaughter of beautiful avenues of trees in both city and country, in order to open a passageway for the wires belonging to a corporation, the members of which plead immunity because of the nature of the utility they are providing for the public. Equipped with spiked climbers and an axe or a saw (usually the former), the employees open up spaces in the tops of trees through which wires may be carried (see Fig. 225). Lacking in appreciation of the beautiful and practicing no economy, these men may disfigure trees which have been the pride of a community for years. They cut the trees back far enough to insure no immediate contact with the proposed line of wires, and thus may leave them in such a weakened condition that, should they ever recover from the shock, they could never develop into anything other than diseased, deformed or dwarfed specimens. (See Fig. 226).

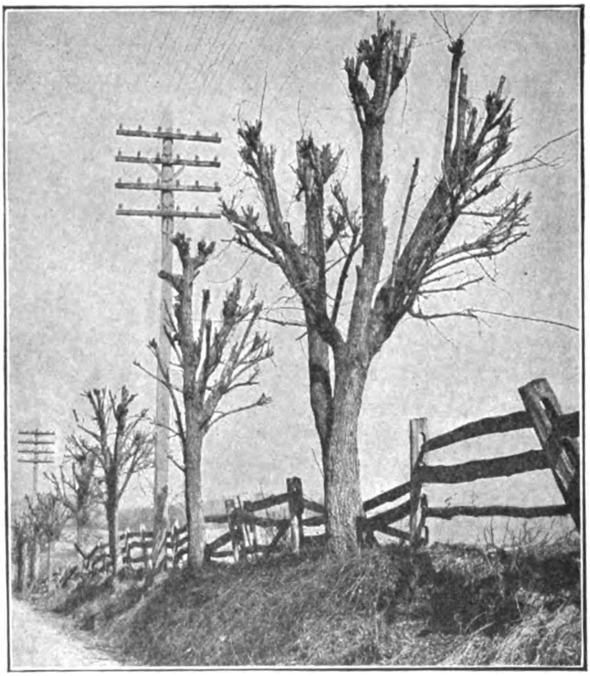

FIG. 226.—*A row of trees dehorned in order to permit the unobstructed passage of overhead wires.*

In this day of large expenditures for the betterment of rural conditions, it is time that these devastations of our street trees were considered seriously by the public, and restraining action taken. (See Municipal Control of Street Trees, p. 483). The adoption of special city and town ordinances can be made to control this matter completely. Such ordinances may provide that if overhead wires must traverse the streets, then some responsible and duly qualified person shall supervise the pruning of the trees, when it is necessary in order to make a passage for wires.

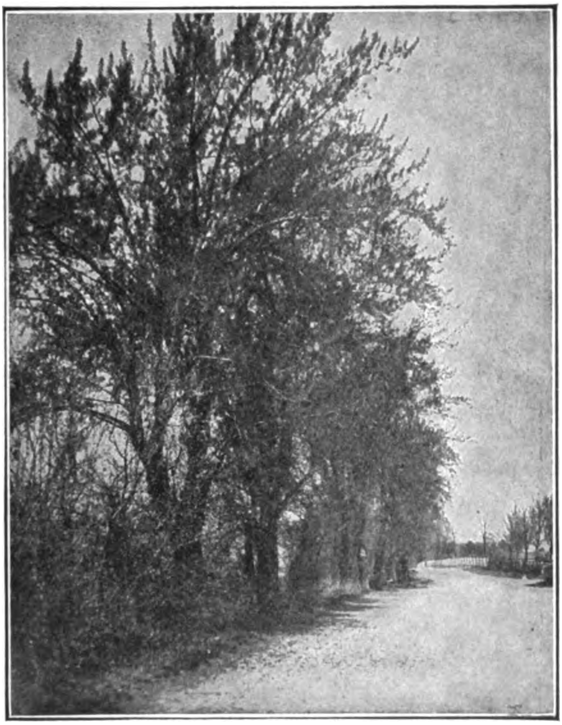

FIG. 227.—*A roadside row of poplars before being trimmed.*

The butchery that is practiced when wires are first strung, and later at intervals to prevent the subsequent growths from coming in contact with the wires, is not the only evil against which the public must protect itself. The removal of broken branches, and of those injured and killed through contact with electric wires, should be supervised, to insure the best development of the tree; and this, also, should require the services of one who thoroughly understands the nature of the work, in order that cuts shall be properly made, wounds properly dressed and protected, and no unnecessary harm done to the tree. Sometimes the linemen who go over the streets to inspect the condition of the trees and wires carry with them instructions to remove all small branches which are interfering with the path of the wires, and to remove no large branches without consulting their employer. Such instructions seem to be very adequate; but there are many young trees whose tops are just coming to

the danger line, and their branches being small are removed without hesitation, while large side branches on big trees are left according to directions. The effect of such a pruning becomes apparent when one realizes that it is not the size of the branch but the relation that it must bear to the future development of the tree, that should govern its treatment. Small branches that are leaders are often more important than large side branches.

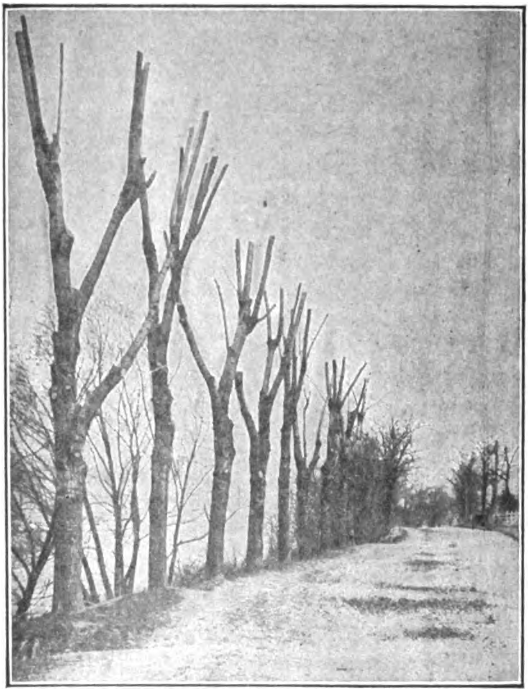

FIG. 228.—*The same row of poplars after having been butchered by "professional pruners."*

The effective method of controlling this evil is to demand that the companies shall place their wires underground. The sight of poles along city streets is not wholly bad, if the street be properly planted; but the danger to trees which seems to be inseparable from the presence of poles will never be overcome while the overhead system is retained.

A suggestion for controlling the placing of overhead wires and overcoming their injuries is that each city and town should adopt one of the following three methods of procedure:

(1.) The construction by the municipality of a conduit, the requirement being made by the local government that the wires of the corporations be placed therein. The initial expense of the construction of such a conduit and of its subsequent maintenance, together with the interest on the money invested, may be covered by requiring each of the companies to pay an annual rental.

(2.) The enactment of an ordinance requiring companies that use any of the main avenues to put their wires underground at the rate of a certain number of miles each year; and that no new lines be permitted to be constructed above ground on the designated streets.

(3.) For the rural districts and the larger towns, these companies might be required to lease a privilege to erect lines of wires across private property; such lines to be a specified distance back from the street and in the rear of the buildings. Thus, to a great extent, these localities would be able to protect their trees.

In the city of Lowell, Mass., the park authorities have adopted an ordinance which requires wires to be covered with wooden tubes wherever they must be carried through the trees. Another means of protection is to fasten the wires to large branches by means of an insulated "eye-pin," which prevents the wire from rubbing against and burning the bark. The chafing of the branches by the wires during wind storms is sometimes quite as fatal to the branch as the burning.

FIG. 229.—*Construction work may be the means of great injury to street trees.*

(2.) *Tree butchery.*

When the writer mentions tree butchery, he has no reference to a certain small but capable group of men who are following the occupation of "tree surgery," and who, through the aid of careful methods, are rendering valuable service to the public. He has in mind those men, who, through ignorance of the fundamental principles which underlie the operations they would perform and yet with the best of intentions, have ruined whole avenues of valuable trees by the very process which was intended to prolong the lives of these trees and to add to their beauty and usefulness.

This kind of injury is of course easily avoided; and each year the perpetration of such offenses against the lives of street trees is becoming less and less pronounced, due partly to the fact that special ordinances have been passed in certain cities, taking away from the individual property owners all direct active control over trees adjoining their property.

To avoid impositions, it is only necessary to establish the standard by employing as pruners only individuals with reputations well established, or with recommendations from competent men.

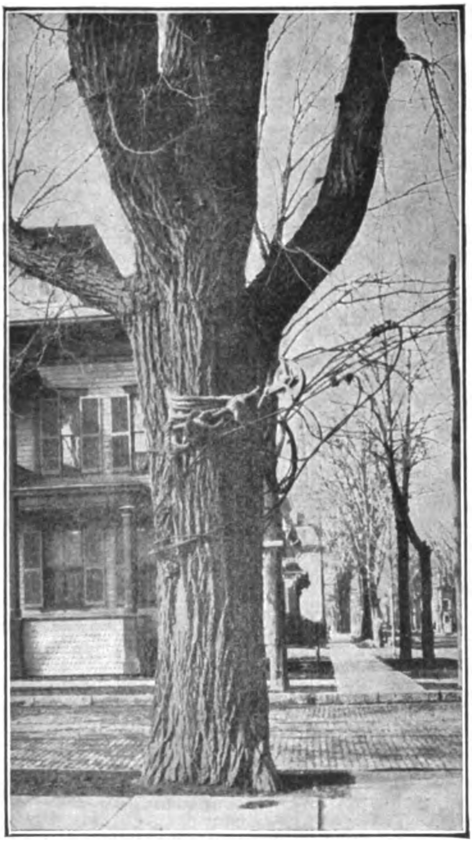

FIG. 230. *A frequent method of attaching guy-wires to street trees, and one which should not be permitted.*

(3.) *Construction work.*

The injuries which trees receive because they are located in the neighborhood of construction work or because they are in the path of buildings which are being moved, present another serious problem to all municipal governments (Fig. 229). Trees are thus mutilated in a number of ways as: by the moving of buildings, being used as supports for guy wires, piling building materials against the trunk, and regrading around the base of the trees. All of these dangers must be guarded against if trees so located are to be preserved. The piling of brick, lumber, and stone slabs close against the trunk may cause injuries which allow decay to enter at that point. Tying guy wires for the purpose of supporting derricks or telephone poles (Fig. 230), is a common practice, and will cause no injury to the tree if properly done. It is done so often without protecting the tree, however, that serious injury results (Fig. 231). The correct method of attaching a wire of this kind to a tree is to place a number of small strips of board against the trunk, parallel to its axis, and then bring the pressure of the wires to bear directly on these (Fig. 233). If the trunk is forked, the wire may be carried between the branches near the crotch and attached to a cross piece which, being placed transversely to the axis of the two branches,

(Fig. 232), brings the pressure to bear on each, and no mechanical injury is caused to the tree. When the pole to be guyed brings little pressure to bear on the wire, a lag-screw may be placed in the side of the tree and the guy wires fastened thereto. In any case, the growth of the tree may continue without the common danger of its being girdled. Telephone companies, who are still the main sources of this injury, are only too willing to have a less dangerous method demonstrated to them. Public sentiment would soon control the situation.

FIG. 231.—*A common injury resulting from the careless attachment of guy-wires.*

FIG. 232.—*A safer way of attaching guy-wires to trees.*

The cutting away of branches in order to make an unobstructed road for the moving of a building along a highway is frequently seen. The reader has probably seen once beautiful elms with one of their main branches cut away, presumably because it was easier to remove the branch entirely than to vary the path of the structure (Fig. 234). Adjacent property owners, knowing that such offenders are guilty of an offense, and that they are laying themselves liable to heavy fines, should obtain from the court an injunction by means of which the work could be delayed until a judgment may be given.

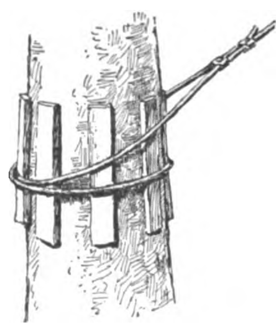

FIG. 233.—*The correct method, if a tree must be used for such purposes.*

The regrading, widening, and general improvement of highways cause annually the unnecessary loss of many beautiful park and avenue trees. Often, with no intelligent person to direct this part of the work, large numbers of trees are removed which could well have remained (Fig. 235). Because a street has been widened, and a valuable tree stands where it may inconvenience traffic a little in the new arrangement, is not sufficient justification for its removal. In such instances, the situation should be carefully investigated and the evidence on both sides considered. The sentiments associated with old landmarks

are often too strong to be considered as trifling. The tree to be removed may be so valuable a factor in the aesthetic life of the community that the inconvenience of going around it will never be great enough to warrant its removal.

In regrading lawn areas it sometimes becomes necessary to make deep cuts or large fills about the bases of trees, which would cause their death were they not properly protected. In general, when cuts or fills average between one foot and three feet in depth, the tree may be preserved by leaving a mound for cuts (see Fig. 236); or, in the case of fills by building a well around the trunk to keep the soil from the bark (see Fig. 237). Trees injured as a result of removing soil from the base, die because the roots dry out; while those injured from fills die because the soil packed around the trunk suffocates that part of the tree, kills the small feed roots, and rots the bark. A few of the very hardy species of trees will survive such conditions of fill, while others are very susceptible to its ill effects.

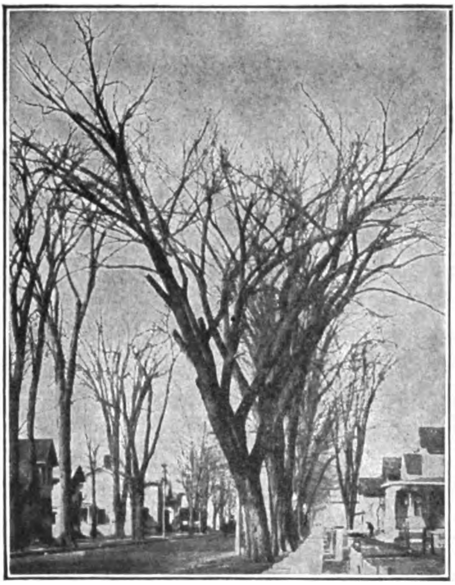

FIG. 234.—*A common practice of pruning trees. These long stubs work serious injury to the tree because of their decay.*

The courts now recognize the fact that the loss of these trees affects the money valuation of abutting property. While a money remuneration is of little or no satisfaction for a property owner or a commission to receive from a tree destroyer, it seems to be the only means at present of checking the difficulty.

(4.) *Wind and ice storms.*

The normal damage to trees through wind and ice storms is due very largely to the improper selection of species. Trees that suffer most from this cause are those with brittle wood, such as white willow and silver maple. The pyramidal trees and also those with excurrent habits of growth, as the gingko and the sweet gum, suffer least, while the broad-headed, vase-formed trees are often seriously

injured. In localities where severe wind storms are prevalent, the evergreens suffer quite as much as the deciduous trees, because the resisting surface is greater at that season of the year when such storms do the most damage. Along the seashore, most of the trees are deformed and usually lean in the direction opposite to that from which the prevailing winds come. Protection can be given best only by a correct selection of deciduous trees, and by keeping from conifers the heavy loads of snow which break the branches during the winter. In many city parks, and along avenues that are lined with very large and old tall-growing trees, it is the custom to cut off a part of the tops, thereby lessening the danger both to the tree and to the public. There is seldom any justification for this, and until such time as the parts of a tree are known to be dangerous, they should not be cut. Keeping a tree free from dead wood will nearly always overcome this danger.

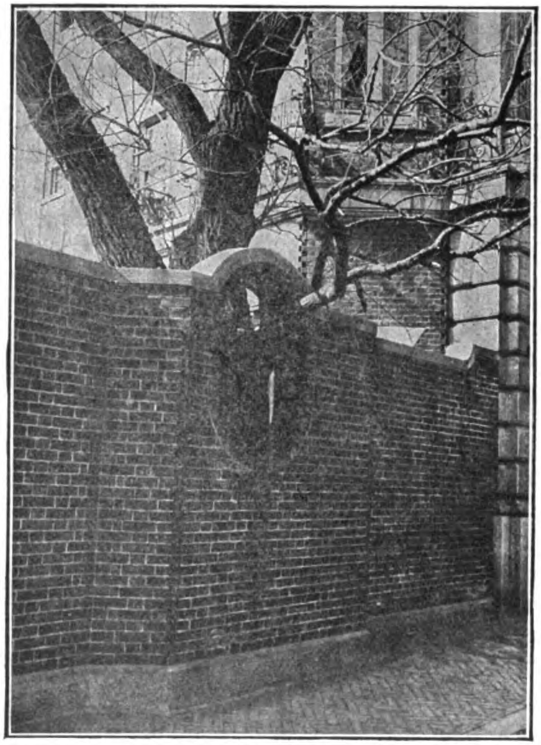

FIG. 235.—*A unique method of preserving an old and valuable specimen of willow.*

(5.) *Freezing.*

Winter-killing of trees from the effects of freezing, and the splitting of the trunks from the same cause, form the basis for many inquiries on the care of trees. The greatest danger from freezing lies not in the fact that many trees in a normal condition of growth are killed back, but rather that improper pruning and unprotected wounds cause cavities to appear on the trunk and larger branches; these fill with water during the summer months, and during the winter months the ice formed in them splits seams up and down these parts of a tree (see Fig. 238). These seams or cracks, small at

first, close during the first summer, but during the succeeding winter are again subjected to freezing processes, which open permanent cracks that continue to increase in size from year to year, and to give free access to the many disintegrating processes of nature. The only pro-

FIG. 236.—*A method of saving valuable trees along streets on which heavy lowering of the grade is being made.*

tection for such a tree is to employ someone, who is fully informed on the methods of tree surgery, to seal the cavity and thus prevent further decay or freezing.

In selecting a species for planting in any particular region, it is best not to accept the advice of a journeyman nurseryman, but rather to seek someone who is acquainted with the climatic conditions of the region, and who knows the degree of hardiness that a species should possess to be grown successfully.

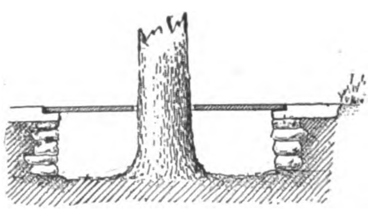

FIG. 237.—*The danger of injuring trees by filling around the base may be avoided by the formation of a "well."*

Young saplings and large branches should be specially protected during the very cold months. In a frozen condition the elasticity of the wood is very much diminished and branches may be broken very easily.

(6.) Bites of horses, and grazing of wagon wheels.

Biting and gnawing of the bark by horses, and the grazing of the bark from the careless driving of vehicles, are other sources of injury, and

many times these injuries cannot be outgrown. In some cities, ordinances provide penalties for the hitching of horses to trees on the highway, and such ordinances should be enforced. When teamsters are heavily fined for committing such trespasses on shade trees, they will use sufficient care to lessen the number of injuries. In one town, the police arrested and caused to be fined some two hundred offenders for tying horses to trees, before drivers became aware of the fact that the laws could be enforced. Each community must expect a certain amount of accidental injury from this source; but no community should permit the custom to prevail of making a hitching post of a tree standing in front of a residence.

Trees that show injury from the above causes, and especially those that have areas of the trunk devoid of bark, should be given attention without delay (see Fig. 240), the ragged edges of the bark being cut to a smooth edge and the entire area covered with paint or tar to protect the wood during the process of healing. Trees in a condition similar to that shown in Fig. 239, should be removed, as it is impossible to save or restore them.

(7.) *Starving of root systems.*

The root systems of trees may be starved in two ways: first, by being confined in a sterile clay soil, and second, by receiving too large or too small water supply.

The trees on city streets suffer most often because of a naturally poor soil and a lack of sufficient water supply. City streets that are macadamized, paved, or concreted, present a surface layer that shuts off almost completely the natural means by which water may reach the roots, and directs all of the surface drainage into catch-basins and sewers. Thus, trees on such streets are subjected to the extreme of adverse conditions, and their natural vitality and soil adaptation must be such that they can withstand the abnormal strain on their

FIG. 238.—*The preservation by means of cement filling of a tree whose trunk has been split from the effects of freezing.*

vitality or they are certain to meet with an unnatural and premature death. Only a very small percentage of the trees used for city work are of the species best adapted to withstand the conditions.

FIG. 239.—*Injuries resulting from the gnawing of horses during the early life of a tree.*

A scarcity of water from the surface, together with an abundant supply from the subsoil, fosters the production of deep-seated roots, which are one of the most valuable assets of a good shade tree. On the other hand, a thoroughly water-clogged soil admits no air circulation, and increases the tendency to the development of surface roots, which are killed during periods of drought; it also provides avenues for root diseases, and finally leads to the death of the tree. Poor soils bring about the condition often known as "stag-head," the symptoms of which are a stunted and sickly appearance of the tree, the presence of slender and weak branches, and a sparsely scattered yellow foliage. The remedy for such a condition depends on its stage of development when detected. In its early stages, the tree may be rejuvenated by digging out a quantity of the poor soil and replacing with good loam; if the specimen shows too great a degree of weakness, it had better be substituted by a younger, vigorous specimen. The Shade Tree Commissioners of Newark, N. J., by means of a small leaflet that they distribute to all prospective tree planters of the city, have accomplished results in partially guarding against the starvation of root systems (see Fig. 241). They require that all holes for newly planted trees shall be of a certain size and filled with good loam in which the roots can feed, and also that a certain open space shall be left around the base of each tree for the entrance of water to the roots. This space is often four feet square, or sometimes rectangular, the long side of the rectangle being parallel to the sidewalk line. Through these open spaces the trees are watered and fertilized when necessary. To prevent the trampling of the earth about the base of the tree, the open space is almost always covered with a movable iron grating (see Fig. 242).

FIG. 240.—*Showing the method of preserving a tree that has been seriously injured by horse bites.*

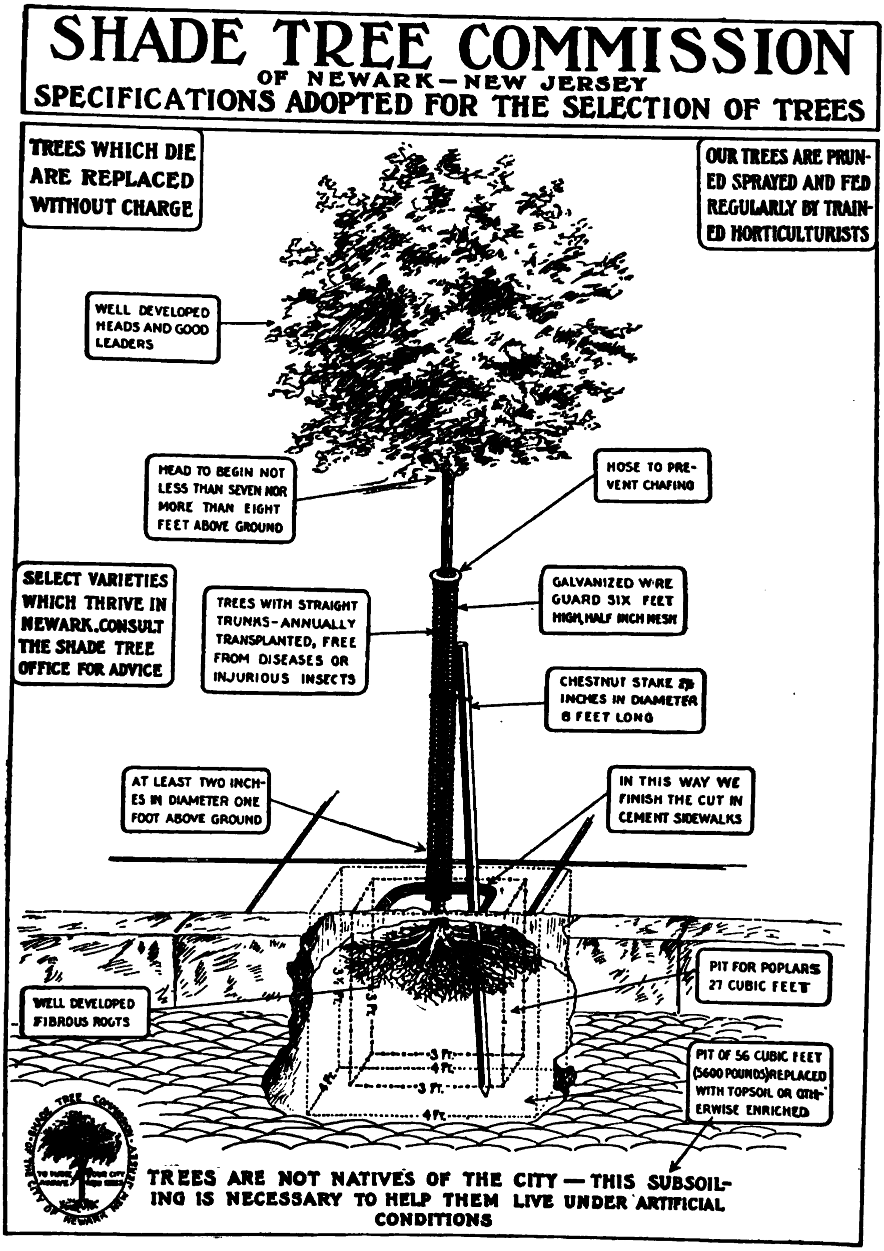

FIG. 241. *A circular (here somewhat reduced) distributed by a shade tree commission. The distribution of a leaflet similar to the above has been useful.*

II

(8.) *Smoke and gas from factories.*

The presence of smoke and atmospheric gases often causes the death or the stunted condition of trees in the streets and parks of our cities. The functions of the leaves are retarded in two ways: first, the breathing-pores or stomata become choked with the soot; and second, many gases in themselves may be poisonous, even when diluted with the atmosphere.

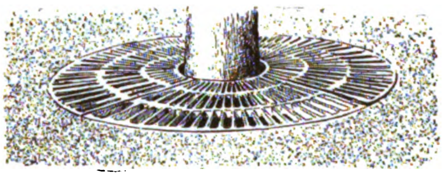

FIG. 242.—*A grating generally covers the "well," and also prevents the area around the base of city street trees from becoming impenetrable to surface water.*

The list of trees that are more or less immune to the effects of smoke and gas is very small, and therefore the range of selection is narrow. Trees should be selected on the basis of results secured with similar species in other cities and towns under similar conditions. The presence of injurious elements often depends on the direction of the prevailing winds. Trees in and around Liverpool show the damaging influences of gases which are carried a distance of fifteen to twenty miles by the prevailing north-west winds. On the other hand, in the vicinity of London these injuries are not so marked. Corporations having factory interests should be urged to control the production of gases, and the municipal authorities in such places should permit no trees to be planted that are not known to be capable of withstanding a certain amount of poisonous vapors and choking of the stomata.

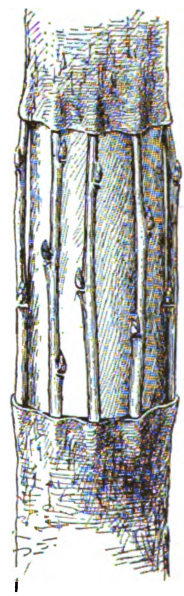

FIG. 243.—*Bridge-grafting, for the preservation of girdled trees.*

(9.) *Overcrowding and improper placing.*

Two kinds of injury result from overcrowding and improper placing of street trees,—the presence of large quantities of dead wood, and the presence of deformed and sickly specimens. The evil begins with the improper spacing of the young trees when first planted, and it continues to increase in proportion to the length of time during which such trees are permitted to remain. The greatest evil attending the close planting of young trees in avenues is the necessity of their removal at a subsequent date, when only a person possessing the courage of his convictions will take out the trees that should be

sacrificed. Citizens who value their trees highly and yet strongly oppose the removal of a few specimens for the good of those remaining, seldom realize the extent of their error. Mere cutting out may not restore the injured trees, if the work is not performed very early in the life of the trees.

Every town and city possesses trees that are suffering from this evil of overcrowding. Each community should designate some intelligent person to direct the work of caring for the pruning of such trees, and who, despite false sentiment, will accomplish the work.

(10.) *Injury from wire labels.*

This injury occurs in young trees which have been labeled in the nursery row and planted in the permanent places without the removal of the labels. The girdling of a tree, whether it be large or small, does not necessarily mean its subsequent death, because some trees more or less outgrow the injury and many have been saved by bridge-grafting the wounded part. This is done by trimming smooth the edges of the girdled part and inserting cions of the same species under the bark in such a way that the wound is bridged over. (Fig. 243.) These cions, being placed very close together around the stem, become united at the ends with the old trunk and serve to conduct the elaborated food material down to the lower parts of the tree. During the period of uniting, the cions are covered with grafting wax much as is an ordinary graft, and no shoots developing from buds on the cions are permitted to grow. In time, as the tree develops, the wounded part is entirely healed.

II. PROTECTION AND PRUNING OF STREET TREES. (Pages 323-337)

A. *Methods of protecting trees.*

Street trees require protection from many contingencies. The three most common sources of injury against which trees must be mechanically protected are, the careless breaking down of young saplings, the abrasions of the trunk caused by wagon wheels, and the drying out of the roots because of lack of water supply. The methods for protection against the many general sources of injury have been outlined, and it is only the protection from these more important injuries which need to be discussed further.

(1). *Protection for young or transplanted trees.* The greatest menaces to the normal development of a young sapling, planted on the highway, are reckless driving and the tying of horses to the tree. As a preventive against the first, all young trees in dangerous positions should be provided with supports to keep them erect and to protect them against

being broken because of bending. The support frequently used for this purpose is a straight, stout pole made from some hard wood. This should be placed firmly in the ground at the base of the tree when the tree is planted, and on the side in line with the row of trees so that it will be least conspicuous; it should be sunk to such a depth in the ground that when the young tree is firmly attached to it by leather (Fig. 244), wire or rope bands, which are kept from the tree by means of a padding of cloth, wool, or any soft material that will protect the tree from injury by binding, it will not be easily blown over or broken by bending. Another method, illustrated in Fig. 245, while more expensive, affords a more secure protection for the young tree. Trees require to be thus protected during a period of three or four years after planting, the length of this period depending on the size of the trees when planted. In general, they cease to need this protection when the trunk has attained such a diameter that only a severe strain would break it.

FIG. 244.—*Young trees must be protected by a soft padding under the bands while staked.*

Young trees, however, are not the only ones requiring support. Older trees, which have been newly transplanted in order to replace dead specimens or to secure an effect quickly, must be protected against wind storms especially, otherwise they may be uprooted. Such protection is afforded by means of three or four guy-wires that may be attached to the upper part of the trunk. Care should be exercised in such work to guard against injury at the point where the wires are attached.

(2). *Protection against horses and wagons.* The injury to trunks of street trees from horse bites and wagon-wheel abrasions is so serious that some means of protection is demanded. Old trees should receive this necessary protection through the enforcement of state laws (p. 464). Young trees, while they may be partially protected in the way previously cited, are more susceptible to this kind of injury, and the injury has greater relative importance in the development of the specimen than would the same wound on a larger tree. With the large number of styles of tree guards now on the market at reasonable prices, there seems to be little excuse for this injury from horses' teeth. Guards may be had at prices ranging from forty or fifty cents up to two or three dollars each. Home-made guards, which are efficient, may be used in country districts; these may be a jacket of

poles, or may be made in the form of a crate. The objection is that they are likely to be unsightly and clumsy. Guards of wire netting are less clumsy and equally as effective as protection against horses, and are commonly used.

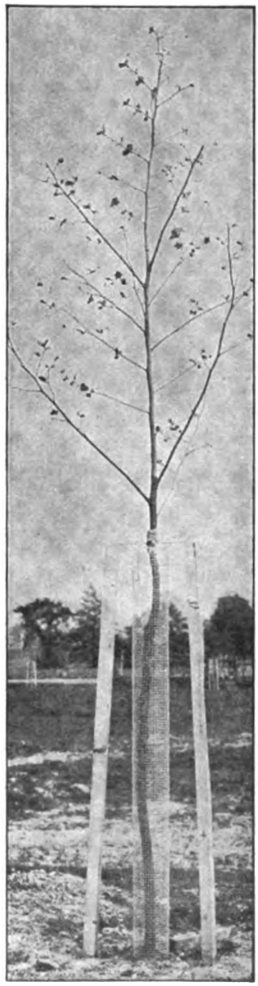

FIG. 245.—*An excellent method of staking and protecting newly planted trees.*

The most economical and best guards may be purchased ready made, from a number of firms. These guards should be removed as soon as the trees attain the size when binding is likely to take place. Such binding is likely to force the upper part of the trunk to grow out over the top of the guard and so lessen the strength of the tree, if not completely to girdle it.

Large trees on the corners of streets where the wheels of passing vehicles may injure them, may be protected by planting a block of stone in front of the tree at an oblique angle, sloping away from the road.

(3). *Protection against drought.* The chief use of grills has been outlined in the discussion of the starving of roots (page 465). Most of the grills on the market are circular or hexagonal in form and are provided with a circular opening in the center which is approximately adapted to the size of the trunks of the trees around which they are to be used. They are made in sections, and are supported on wooden pegs driven firmly in the ground. As a means of securing the desired open spaces around the trees and at the same time not interfering with the traffic, there is nothing better. Their use in cities offers almost the only method of protecting trees against the dangers from paved streets.

(4). *Protection against winter-killing.* The necessity of affording winter protection for many species of ornamental trees and shrubs is great. However, while protection is sometimes given to certain species of young shade trees, it is not a profitable practice for two reasons. First, because a species of shade tree should be chosen that is perfectly able to withstand the normal climatic conditions of the locality. Second, because any such tree which winter-kills back each year will naturally

require a greater or less amount of pruning to retain it in a normal condition, and it can never develop to its maximum beauty and size; therefore it should be replaced by a more hardy species which will not require so much care and protection. (See page 463.)

B. Pruning of street trees, and tree surgery.

The presence on street trees of ugly wounds, large cavities, and the projecting stubs of dead branches, are indications that such trees have been grossly neglected or carelessly treated. Improper treatment is so common that losses through the neglect of pruning or the practice of incorrect methods assume enormous proportions.

The amount of pruning that is necessary to preserve a tree in its best condition varies greatly with the species and type of the tree. It is quite as easy to prune a tree too often and too much, as to prune not enough. In general, trees along highways require very little attention; but what attention is needed must be given at the proper time and in an intelligent way. Pruning may be undertaken for the following purposes:

(1). To remove dead wood and injured branches.

(2). To secure a stronger and more vigorous growth.

(3). To open up the head of the tree and to reduce competition among the branches.

(4). To adapt the species to street purposes as shade trees.

(5). To control the production of flowers.

(1). *Removal of dead wood and injured branches.* Old trees, crowded trees, and those that have been subjected to the detrimental influences of gas and overhead wires, require a certain amount of pruning to preserve them in a normal condition. In such cases, the practice should be to remove each year dead or dying branches, and to cut back below the point of injury those branches that have been injured in any way. Trees that have developed the condition known as "stag-head," which is evidenced by a dying out of the top, should have the dead parts removed and the other parts cut back slightly to conform to the shape of the tree.

(2). *To secure stronger and more vigorous growth.* The significance of this operation is explained by saying that if we remove a part of a tree, the food supply which would have gone to that part is distributed throughout the remaining parts of the tree, and in consequence these parts make a more vigorous growth. While this is a common practice among trained tree pruners for rejuvenating old and weak specimens, and to

establish transplanted specimens, yet its successful application under different conditions requires years of experience. Trees that have been root-starved or suffocated with gas are often preserved by this practice.

(3). *To open up the head of the tree.* It frequently happens that trees become crowded and cannot attain their normal and best development without being subjected to a thinning process. As a rule, street trees should be adapted to specimen planting, and the full development of such trees cannot be expected under crowded conditions. The interior of the trees should have free light and air. Competition for light among the branches can be reduced greatly by removing those which in the course of time must be crowded out and suffocated. Trees that are suffering from overcrowding of branches should be intelligently thinned out, in order that the branches that remain may develop a greater leaf surface.

(4). *To adapt the species to street purposes as shade trees.* It is seldom necessary to prune certain species of trees to adapt them to street plantings. Trees should not be chosen that must be pruned continually in order to make them desirable. Occasionally one may find an avenue of trees that are not adapted to their situation. In such instances, rather than cut the trees down, the avenue may be made attractive by judicious pruning, as by removing or shortening in some of the branches, or removing such lower branches as may interfere with traffic. Occasionally, because of the breaking of a branch during a storm, it becomes necessary to develop a branch to fill the gap and restore the symmetry of the tree. This is done by selecting a branch and cutting it back to a branchlet that points in the direction of the gap, and then encouraging the development of this branchlet.

(5). *To control the production of flowers.* Street trees are not valuable primarily because of their flowering habits, and frequently it happens that trees are objectionable because of this feature, since the presence of showy flowers subjects them to much damage from marauding persons. This is especially true of the tulip tree, flowering dogwood, horse-chestnut and magnolia. Such trees as flowering dogwood and some of the magnolias, which flower early in the spring and on wood formed the year before, require pruning after the trees are done flowering each year. Pruning previous to the time of flowering removes a number of flower-buds already formed, whereas pruning immediately after flowering serves to encourage the growth of new branchlets on which will be formed more flower buds for the succeeding year. Pruning to control the production of flowers is practiced more extensively with shrubs than with trees.

The amount of pruning required by trees on city streets and country highways is comparatively small. Pruning is necessary, however, in very young trees that are establishing their form, and in old specimens that must be rejuvenated by artificial means. Young trees are usually vigorous and rapid growers, and the least influence may produce a strong or weak growth which may greatly affect the form of the mature tree. Especial care is necessary in the case of specimens collected from the woods, and of nursery stock which has not been trained correctly. The main attention required by young trees is to remove crowding branchlets, to cut back overvigorous growths, and to encourage an upright growing shoot called a leader, all of which aims to enhance the natural beauty of the specimen.

FIG. 246.—*The incorrect way in which to remove large branches.*

Young elms perhaps require as much pruning as do any other species of street trees. Uniformly developed specimens of these trees may be selected from the nursery, and yet when transplanted in an avenue they will soon show their characteristic uneven development in both form and size. They should be so trained that the broad and strong forks will be developed in preference to the narrow and weak ones, in order to avoid the liability to subsequent splitting.

FIG. 248.—*A "monument to the memory of the pruner," and a common disfiguration on our shade trees.*

Season for pruning. The correct season to prune trees cannot always be definitely set. The time for pruning street trees may cover a wider range than does that for pruning certain ornamental trees and shrubs in which the season for producing flowers must be considered. The difference lies in the differences in the purposes for which the pruning is done. While pruning may be performed at almost any season of the year, yet pruning in the summer months is attended with numerous difficulties. The most advantageous seasons for this work are in the early spring, previous to the beginning of the growing period, and the late summer or autumn. Of these two, the time between late February

FIG. 247.—*The correct way in which to saw a limb to prevent splitting.*

and early April is preferable. An exception to this, however, occurs in the case of maples. These trees bleed very freely when cut in early spring, and professional pruners have found that the best season for pruning them is during the summer months. This loss of sap is not recognized as being injurious to the tree; but the wounded surfaces may be protected more easily in summer pruning.

FIG. 249.—*The correct method of making a cut.*

In choosing the season for pruning trees, it must be kept in mind that the healing of the wounds depends on the growth of the cambium. We see, therefore, that in very dry and severe climates, the exposed freshly cut and unprotected tissue may be killed back during the winter months. On the other hand, wounds made just previous to the growing season and which are adequately protected, will become partially or wholly covered by the new layers from the cambium during the same spring, and in a short time the cut will be completely healed over. It is unreasonable to expect a large wound to heal in a single season; but the ordinary wound on a tree which has been pruned judiciously since planting, will be healed in a single season sufficiently well to warrant its being left unprotected artificially thereafter.

FIG. 250.—*Insufficient protection and constant weathering leave an otherwise clean wound open to decay.*

Making the cut. This operation more often than any other, has resulted in fatal injury to the tree. Authorities agree that most of the injuries to shade trees from fungi may be traced directly to poor pruning and mechanical injuries, and they have shown that there are various wound fungi that develop only as a result of poor pruning. Incorrect methods of antiseptic protection have also aided in bringing about the evil results.

Removing large branches may be attended by injury to the tree by breaking and tearing strips of bark and wood from the trunk below their points of attachment (see Fig. 246). To avoid this, two cuts are made, first one on the under side of the branch, about one foot from the main trunk, and the other on the upper side of the branch (Fig. 247), thus removing all but a stub extending out from the trunk. The stub is then removed by first making a slight cut on the under side to insure against any possible splitting of the wood, and then cutting

from the upper side, care being taken to see that the second cut is made flush with the bark of the trunk (Fig, 249). The healing process is greatly impeded by any ragged edges left by splitting or careless sawing.

An equally important factor is that the pruner should leave no part of a cut or dead branch on the trunk. Old wood cells possess no life, and hence, when a branch is severed, if it be of any size, the exposed wood of the inner area can never heal through any growth of itself. It must depend for its ultimate protection on the cambium, which, supplied with food from the roots and leaves, grows and expands at the point where the cut is made, and the new tissue rolls out over the wounded surface and in time entirely protects it. To get the best results, this wounded area must be in close proximity to the path of the food supply.

FIG. 251.—*A noble specimen of white oak fast outgrowing its period of use fulness. Such trees might easily be preserved by the simplest methods of careful tree surgery*

Stubs soon dry out at the ends, the bark loosens (Fig. 248), rolls back and falls off, leaving the dead stub which finally rots back to the main trunk and forms the beginning of a cavity. This cavity, very small at first, collects water in larger quantities each succeeding season until finally the entire interior of the tree is rotted.

All cuts should leave the wounded surface flush with the plane of the bark on the parent branch (Fig. 249). No ragged edges should be left on the wood, and no part of the stub should project beyond the surrounding cambium. The cut surface should never be made with an axe or a hatchet. Cuts can best be made with the aid of a sharp saw, and a chisel with which to smooth the surface, special precautions being taken to avoid any irregularity on the wounded surface in which water may collect.

The work of pruning a large tree should begin at the top and be continued as the pruner descends. In this way the operator is less likely to overlook any branches that may be broken by the falling of branches from above. The pruner should be careful not to break or bruise healthy branches.

Protecting wounds. It has been pointed out that the natural healing of a wound is the result of the growing tissue, and that in large

cuts the period of healing may occupy two, three or more years (see Fig. 250). During this healing period protection must be given to the surface to keep out all moisture and prevent evaporation and subsequent drying of the dead inner wood. If this is not done, the spores of fungi enter and help to decay the exposed area.

Protection is necessary on all large wounds (more than 1½" in diameter), and on all smaller wounds that are the result of fall and early winter pruning. As soon as the wounds are made, some substance should be applied to the surface which will serve as an antiseptic and also as a preventive against evaporation and water. Bordeaux mixture may be applied as an antiseptic, if desired; but it is not permanent as a covering against evaporation. Tar and lead paint are the best mixtures for this work, the latter being preferred by the majority of professional pruners. Dressings used on fresh wounds of pruned trees should in all cases be preservative and preventive, and in no case should they be such as might injure the tissues.

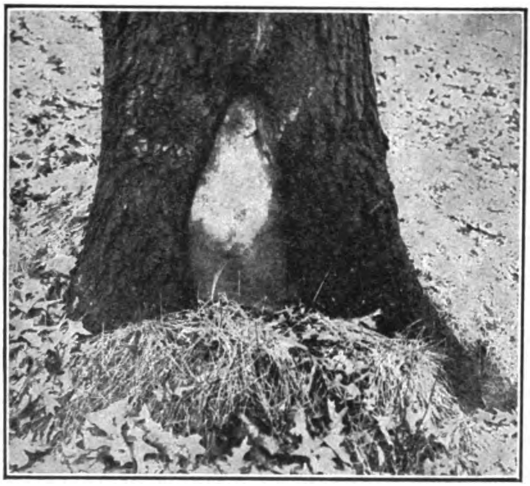

FIG. 252.—*A well filled cavity preserves the tree against further decay.*

Protective substances are applied in a thick layer, and one covering is generally sufficient for small wounds; for large wounds a second coat is put on during the second or third year, and if several years are required for the healing, the surface should receive attention each year in order to avoid any chance of decay. A common practice is to cover very large wounds with dressing, and over the whole place a covering of tar paper which will serve to increase the efficiency of the dressing. Tar is not much in favor as a dressing among professional operators as compared with white lead, which is more permanent and less repulsive to the eye. However, tar possesses the advantage that, when applied hot, it strikes into the wood, thus making it a most desirable dressing to be used on the wounds of maple trees during the spring months when paint will not adhere.

Tree surgery. Systematic pruning and tree surgery are very closely related. Tree surgery includes the intelligent protection of all mechanical injuries and cavities. Pruning requires a previous intimate knowledge of the habits of growth of trees; surgery, on the other hand, requires in addition a knowledge of the best methods for making cavities air-tight and preventing decay (Fig. 252). The filling of cavities in trees has not been practiced sufficiently long to warrant making a definite statement as to the permanent success or failure of the operation; the work is still in an experimental stage. The caring for cavities in trees must be urged as the only means of preserving affected specimens, and the preservation of many noble specimens has been at least temporarily assured through the efforts of those practicing this kind of work.

FIG. 253.—*A cavity in the process of being filled; rubble masonry or brick being used for the outer wall of the concrete filling.*

Successful operation depends on two important factors: first, that all decayed parts of the cavity be wholly removed and the exposed surface thoroughly washed with an antiseptic; second, that the cavity, when filled, must be air-tight and hermetically sealed, if possible. Trees are treated as follows: The cavity is thoroughly cleaned by removing all decayed wood and washing the interior surface with a solution of copper sulfate and lime, in order to destroy any fungi that may remain. The edges of the cavity are cut smooth in order to allow free growth of the cambium after the cavity is filled (see Fig. 253). Any antiseptic, such as corrosive sublimate, creosote, or even paint, may answer the purpose; creosote, however, possesses the most penetrating powers of any. The method of filling the cavities depends to a great extent on their size and form. Very large cavities with great openings, are generally bricked on the outside, over the opening, and filled on the inside with concrete, the brick serving the purpose of a retaining wall to hold the concrete in place. Concrete used for the main filling is usually made in the proportion of one part good portland

cement, two parts sand, and four parts crushed stone, the consistency of the mixture being such that it may be poured into the cavity and require little or no tamping to make the mass solid. Fillings thus made are considered by expert tree surgeons to be a permanent preventive of decay. The outside of the filling is always coated with a thin covering of concrete, consisting of one part cement to two parts fine sand. Cavities resulting from freezing, and which, though large on the inside, show only a long narrow crack on the outside, are most easily filled by placing a form against the entire length of the opening, having a space at the top through which the cement may be poured. Another method of retaining the concrete is to reinforce it from the outside by driving rows of spikes along the inner surface of either side of the cavity and lacing a stout wire across the face of the cavity. For best results, all fillings must come flush with the inner bark when finished. During the first year, this growing tissue will spread over the outer edge of the filling, thus forming an hermetically sealed cavity. In the course of time, as the cambium continues to expand, the outside of small or narrow openings should be completely covered with living tissue, which buries the filling from view.

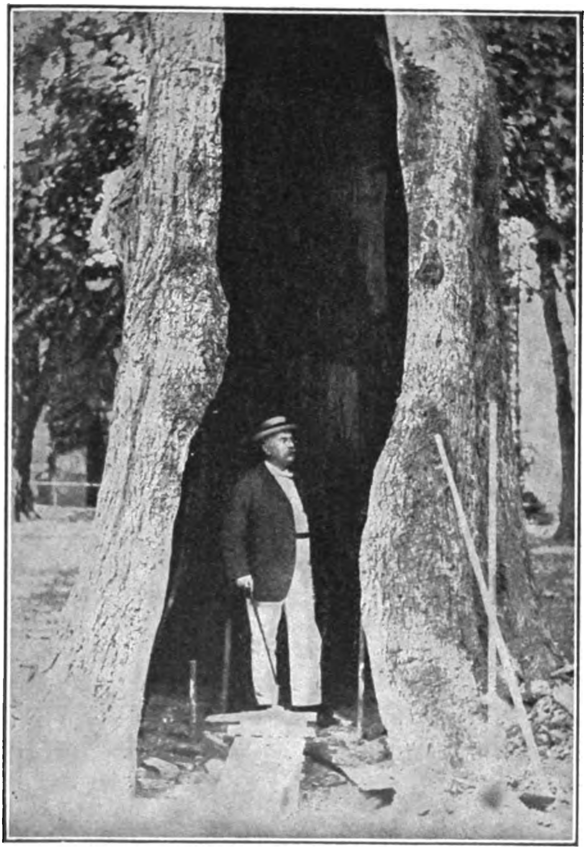

FIG. 254.—*A large tree requiring immediate attention, if the specimen is to be preserved.*

It has been found that there is a tendency for portland cement to contract from the wood after it dries, leaving a space between the wood and the cement through which water and germs of decay may enter. A remedy for this defect has been suggested in the use of a thick coat of tar, or an elastic cement which might be spread over the surface of the cavity before filling. The cracking of portland cement on the surface of long cavities, is caused by the swaying of trees during heavy storms, and should not occur if the filling is correctly done.

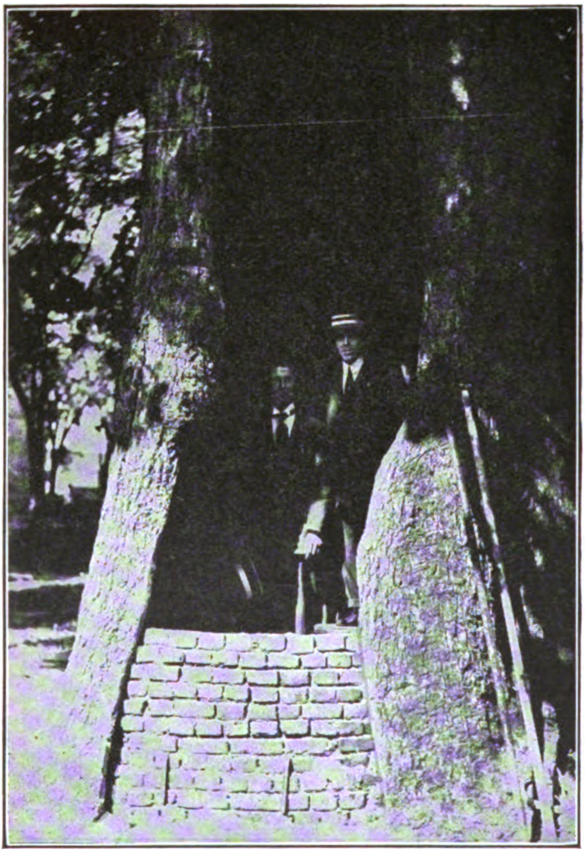

FIG. 255.—*The same cavity (Fig. 254) in the early stages of filling; bricks are used to retain the concrete.*

In addition to the preservation of decayed specimens by filling the cavities, as above outlined, it has been proposed to strengthen the tree by treating it as shown in Fig. 257. Young saplings of the same species, after having become established as shown, are grafted by approach to the mature specimen.

Bolting and chaining trees. Injury frequently results from error in the method of attempting to save broken, or to strengthen and support weak branches which are otherwise healthy. The means used for supporting cracked, wind-racked, and overladen branches which show a tendency to split at the forks are bolting and chaining. The practice of placing iron bands around large branches in order to protect them has resulted in

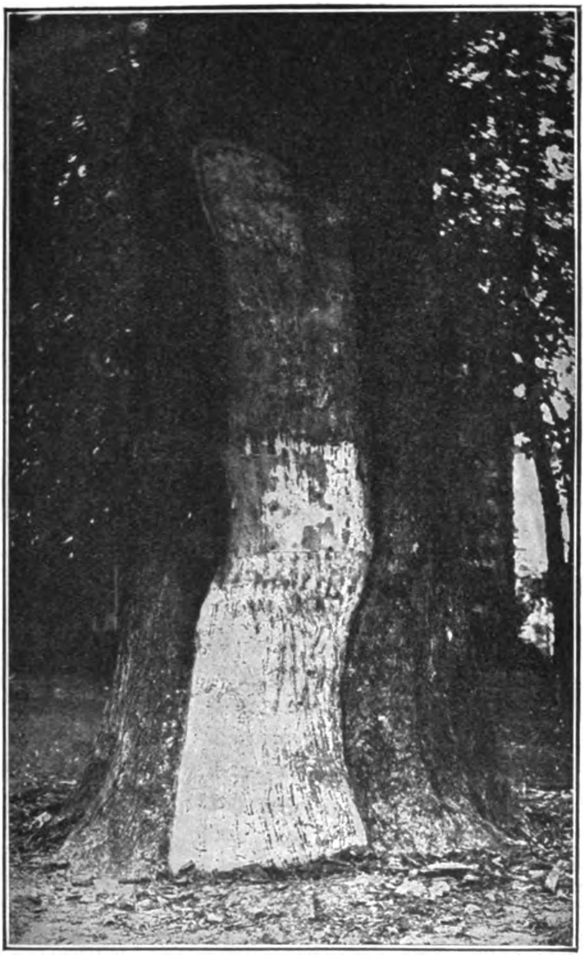

FIG. 256.—*The same cavity (Fig. 255) completely filled and finished; note the clean cut edges of the cavity.*

much harm; as the tree grows and expands in diameter, such bands tighten, causing the bark to be broken and resulting after a few years in a partial girdling (Fig. 258).

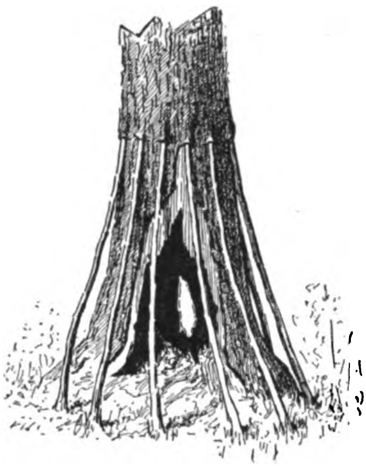

FIG. 257.—*A method of re-establishing a valuable specimen—through the grafting by approach of young saplings of the same species.*

To bolt a tree correctly is comparatively inexpensive. The safest method consists in passing a strong bolt through a hole bored in the branch for this purpose, and fastening it on the outside by means of a washer and a nut. Generally the washer has been placed against the bark and the nut then holds it in place. A better method of bolting, and one which insures a neat appearance of the branch in addition to serving as the most certain safeguard against the entrance of disease, is to countersink the nut in the bark and imbed it in portland cement (Fig. 259). The hole for the sinking of the nut and washer is thickly coated with lead paint and then with a layer of cement on which are placed the nut and washer, both of which are then imbedded in cement. If the outer surface of the nut be flush with the plane of the bark, within a few years it will be covered by the growing tissue.

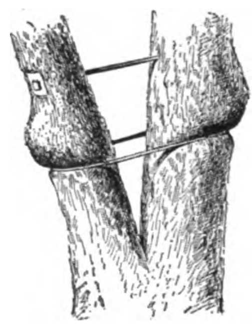

FIG. 258. — *Undesirable methods of bracing shade trees.*

The inner ends of the rods in the two branches may be connected by a rod or chain. The preference for the chain over the rod attachment is based on the compressive and tensile stresses which come on the connection during wind storms. Rod connections are preferred, however, when rigidity is required, as in unions made close to the crotch; but for tying two branches together before they have shown signs of weakening at the fork, the chain may best be used, as the point of attachment may be placed some distance from the crotch, where the flexibility factor will be important and the strain compara-

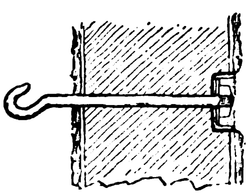

FIG. 259. — *Care should be exercised in seeing that the bolts are properly inserted.*

tively small. Elms in an advanced stage of maturity, if subjected to severe climatic conditions, often show this tendency to split. These trees, especially, should be carefully inspected and means taken to preserve them, by bolting if necessary.

III MUNICIPAL CONTROL OF STREET TREES. (Pages 337-343)

In the greater number of our larger cities and in a few of the smaller ones, the care and preservation of the shade trees is, to a greater or less degree, under the direct supervision of a commission specially appointed for this purpose, or under the general supervision of the city park commission. On the other hand, in towns and cities where no such methods can be adopted, the control of the trees is vested in an official who carries the title of tree warden. The laws of New York provide for the appointment of tree wardens in every community, and in many states the laws now make provision for the appointment of shade tree commissions. The number of cities in which such commissions are appointed is increasing each year. Theoretically, organizations similar in character to park commissions and tree wardens, having the laws of the state behind them, should prove efficient in controlling shade tree interests. In practice the results have often been unsatisfactory. In the smaller towns, the office of tree warden is unremunerative, and no incentive is offered for a capable person to accept the responsibilities of the position.

We must realize that the planting, subsequent care, and protection of street trees should be under the direct control of the municipal government to just as great a degree as the paving of a street or the removal of garbage. One of the gravest mistakes is that of permitting adjacent property owners to exercise their individual judgments in the selection of stock with which it is proposed to plant the highway. In many cases, property owners who may have become enthusiastic through the inspiration of a local improvement society are often quite ignorant of the relative merits of the species of trees and their adaptation to any particular location. Therefore they admire the fine cuts to be seen in the catalogues of nurserymen, and read the glowing descriptions. Their neighbor does the same. The result is that the plantings may be irregular, unattractive, and repulsive. In other cases, where a number of individual property owners have worked in unison, they have succeeded in establishing fine plantings of young trees full of promise for future development. But under such a voluntary system, trees are likely to be neglected, and replaced sooner or later. Further-

more, it is a difficult task to obtain the concerted action of property owners which is necessary to insure the planting of the entire length of a street with uniform and properly selected stock of a desirable species.

To control the planting of street trees most economically and to insure uniform material, each large city should have its own nursery in which can be grown the species best adapted for its use. Nurseries of this kind, supported from a municipal appropriation, are valuable assets to the city, as has been proved by the experience of Washington, Paris, Philadelphia, and Chicago. Such nurseries may be made to supply trees not only for street and avenue planting, but also for city parks, squares and public gardens. Small cities and towns cannot afford the expense of maintaining a nursery, and their only resource lies in the judicious appointment of men to control the selection of their shade trees. Such precautions will assure satisfactory results.

Each citizen should be as deeply interested in the ordinances that control the shade-tree conditions in his community as in those that regulate the street cars or the telephone lines. The laws which already exist in certain states are sufficiently well framed so that most of the injuries to trees in cities and rural districts might be checked, were these laws strictly enforced. One criticism of many of these laws is that they do not deal severely enough with the offenders. A number of cities, mainly in the states of Pennsylvania and New Jersey, have recently adopted special sets of city ordinances that place the control of all the trees of the city under the jurisdiction of a special Shade Tree Commission. The laws of these two states give the entire control into the hands of the city authorities, and if these authorities feel disposed to take such control, as evidenced by the appointing of these commissions, then all offenders of the city ordinances are punished directly through these commissions and their representatives. Such commissions have full and undisputed power to plant, remove, spray, and prune any or all of the trees within the boundaries of their jurisdiction. Special ordinances, while not necessary in rural districts, are highly commendable; they give to the municipal government a more personal control over the work than would be given by the state laws alone. Such commissions having been established, it then becomes the duty of the citizens annually to make provision for the appropriation of sufficient funds to meet the expenses of the commission.

Special ordinances are particularly adapted to city problems. For the rural districts, however, the state laws would at the present time be the means of preventing the wholesale butchery of our trees, were they strictly enforced. Here is where the citizens fail to use the

power at their command. Companies are permitted to slaughter beautiful avenues of trees; and owing to lack of information regarding the laws of the state, the adjacent property owners remonstrate with the offenders and finally accept a paltry remuneration for the damage done, or reluctantly accept their lot as one of the necessary misfortunes. It is safe to say that the greater proportion of the citizens are ignorant of the nature of these ordinances, all of which have been framed for their good. We here mention a few salient features from some of the ordinances of different states in order to indicate what has been done in the interests of the people.

New York.

Penalties are prescribed for anyone who shall injure a tree, or who shall hitch a horse or any other animal to a tree, or leave the same standing near enough to injure a tree used for shade or ornament, at "any school-house, church, or public building, or along any public highway."

Massachusetts.

The state supreme court has rendered a decision that wire companies have no right to trim trees without proper permission, and the park authorities impose a fine of $20 for each offense.

Penalties provide that: Whoever injures, defaces, or destroys any designated tree shall forfeit not less than five nor more than one hundred dollars.

Whoever affixes to any tree in a public way or place, a play bill, picture, announcement, notice, advertisement, or other thing, whether written or otherwise, or cuts, paints, or marks such trees, except for the purpose of protecting them, and then under a written permit from the tree warden, shall be punished by a fine not exceeding $50 for each offense.

Whoever wantonly injures, defaces, breaks, or destroys an ornamental or shade tree within the limits of any public way or place, shall forfeit not less than five nor more than one hundred dollars, to be recovered by complaint, one-half to the complainant and the other half to the use of the town.

New Hampshire.

Towns and cities shall control all of the shade and ornamental trees within the public highways, which the warden deems reasonably necessary. Such trees shall be marked by the warden.

Penalties are imposed for cutting and defacing trees except with the consent of the warden.

Provisions are made prohibiting owners of land from burning brush near the trees.

Pennsylvania.

By means of a petition from a majority of the property owners on any public street, the town council may require, by ordinance, the planting of shade trees along that street; and on the failure of any owners to plant, it may cause the planting to be done, and collect from the adjoining property owners.

Any person who cuts or injures any shade tree or other tree shall pay a penalty of one to five dollars for each offense; or he may plant and maintain another tree in place of the one cut or injured.

New Jersey.

In all municipalities there may be appointed a Commission of three freeholders, without compensation, who shall have control of trees and power to plant and care for shade trees on any of the public highways.

Cost of planting, including guards around trees, to be borne by the adjoining real estate. The same may be collected with the taxes. Cost of maintaining to be borne by municipality.

The foregoing are extracts from the ordinances of the states in which this question is most important. They reveal the fact that the damage now being done to shade trees, to a certain extent, can be effectively controlled without the aid of special ordinances which invoke special penalties. As one writer has said, "the absence of shade trees on many of our streets and highways is not due to any lack of legislative provision for their planting, care and maintenance;" it is due to a lack of stimulation of public interest and enthusiasm in this work.

The two foremost states in the Union in this work in all probability, are Pennsylvania and New Jersey, and in these states the legislatures have passed ordinances which provide for the care and planting of shade trees on highways of townships of the first class, boroughs, and cities of the commonwealths. The laws of New Jersey were passed in 1893, and after lying dormant for a number of years were supplemented in 1905 and again twice supplemented in 1906; those of Pennsylvania were passed and approved by the legislature in 1907. The following summary of these state laws will illustrate ordinances which will insure careful management of shade trees by empowering the Shade Tree Commission if necessary to enforce additional ordinances which meet the requirements of their particular problems.

Section 1. Provides that in townships of the first class, and cities of the Commonwealth, there be appointed a commission of three freeholders, who shall serve without compensation, and who shall have exclusive and absolute control of, and power to plant, set out, remove, maintain, protect, and care for shade trees on any of the public highways of their respective municipalities; the cost thereof to be provided for in the manner hereinafter directed. Such commission to be known and designated as the Shade Tree Commission.

Section 2. Provides that it shall be optional with the governing body of any municipality whether this act shall have effect and such commissioners shall be appointed in such municipality; and when any such governing body shall by resolution formally approve of this act and direct that such commissioners shall be appointed, then, from that time, this act and all of its provisions shall be in force and apply to such municipality, and such commissioners shall be appointed for terms of three, four and five years, respectively; and on the expiration of any term, the new appointment shall be made for five years, and any vacancy shall be filled for the unexpired term only; and in cities, the said appointments shall be made by the Mayor thereof; in townships by the commissioners, or by the chairman of the township committee. In towns and cities where a commission already exists, the term and appointment of such Commission shall not be changed by this act. Such Shade Tree Commission shall twice in each year report in full its transactions and expenditures for the municipal fiscal year last ended.

Section 3. Provides that when such commissions shall propose the setting out, planting, and removing of any shade trees, or the material changing of the same in any highway, they shall give public notice of the time and place appointed for the meeting at which such contemplated work is to be considered, specifying in detail the highways, or portions thereof, upon which trees are proposed to be planted, removed, or changed, in one or more—not exceeding two in all—of the newspapers published in said township or city, for at least two weeks prior to the date of such meeting.

Section 4. Provides that the cost of planting, transplanting, or removing of any shade trees in any highway, and of suitable curbing, guards or grating for the protection thereof, when necessary, and of the proper replacing of any pavement or sidewalk necessarily disturbed in the doing of such work, shall be borne by the owner of the real estate in front of which such trees are planted, and such amounts as may be assessed to the different owners shall become liens upon the real estate in front of which such work has been done and shall be collectible in the same manner as the liens for taxes are now collectible against the property involved.

Section 5. Provides that the cost and expense of caring for the trees after having been planted and set out, and the expense of publishing the notices provided for in Section 3, shall be paid for by a general tax, to be levied annually in the manner that taxes for the township, borough and city purposes are now levied, such tax not to exceed the sum of one-tenth of one mill on the dollar on the assessed valuation of the property. The needed amount each year shall be certified by the Shade Tree Commission to the proper authorities charged with the assessment of taxes in said township, etc,, and paid in the same manner as other taxes are paid.

Section 6. Provides that the Shade Tree Commission shall have power to employ and pay superintendents, engineers, tree wardens, foresters, and other assistants as its proper performance of duties shall require; and to make, publish, and

enforce regulations for the care of, and to prevent injury to, the trees on the highways; and to assess suitable fines and penalties for the violations of these ordinances, and such fines and penalties shall become liens upon the real property of the offender.

Section 7. Provides that all moneys due and collected from liens or penalties or assessments shall be paid to the treasurers of the townships, boroughs, and cities, and shall be placed to the credit of said Commission, subject to be drawn upon by the said Commission for the purposes of this act.

The foregoing are summaries of sections which are included in the acts of New Jersey and Pennsylvania, and which give to the governing bodies of the towns, boroughs, and cities in these states certain powers that if supplemented by sets of special city ordinances will enable the citizens completely to protect the shade trees. The following is an outline of such a set of ordinances relating to the protection, regulation and control of shade trees and city parks. Such ordinances have been successfully adopted by the Shade Tree Commissions of Newark, N. J., East Orange, N. J., and Cleveland, O.

Section 1. Provides that no person shall, without the written permit of the Shade Tree Commission, cut, break, climb with spikes, injure, or remove any living tree in a public highway, or any tree or plant in a city park; or injure, misuse, or remove any device placed to protect such tree or plant, or have possession of any such structure or part thereof.

Section 2. Provides that no person shall leave any paper or other waste material in a city park, except in receptacles which may be provided therein for such material.

Section 3. Provides that no person shall enter upon any portion of lawn or ground within a city park when notified by a sign placed in such park, or by a guardian of such park, or by a police officer, not to enter upon such lawn or ground.

Section 4. Provides that no person above the age of fourteen years shall, except at such places and under such regulations as may be designated by the Shade Tree Commission, play at any game in a city park.

Section 5. Provides that no person shall, without the written permit of the Shade Tree Commission, place any booth, stand, or other structure, or station any wagon or other vehicle in a city park.

Section 6. Provides that no person shall offer any article for sale, display any advertising device, or distribute any circulars or cards in a city park.

Section 7. Provides that no person shall fasten a horse or other animal to a tree in a public highway, or in a city park, nor cause a horse or other animal, to stand so that said horse or animal can injure such a tree.

Section 8. Provides that no person shall, without a written permit from the Shade Tree Commission, attach or keep attached to a tree in a highway or park, or to the guard or stake intended for the protection of such tree, a rope, wire, sign or any device.

Section 9. Provides that no person shall, without the written permit of the Commission, place, or hereafter maintain, upon the ground in a highway or city

park, stone, cement, or other substance which shall impede the free entrance of water and air to the roots of any tree in such highway or park, without leaving an open space of ground outside the trunk of said tree, in area not less than four square feet.

Section 10. Provides that in the erection or repair of a building or structure, the owner thereof shall place such guards around all nearby trees on the highway as shall effectually prevent injury to them.

Section 11. Provides that every person or corporation having any wires charged with electricity running through a public highway or park shall securely fasten or protect such wires so that they will not come in contact with any tree therein. (An improvement on this section would be the addition of a supplementary clause, providing that on certain highways the companies controlling such wires should be required to place them in an underground conduit.)

Section 12. Provides that no person or corporation shall prevent, delay, or interfere with the Shade Tree Commission or its employees in the planting, pruning, spraying, or removing of a tree in a public highway or a park, or in the removal of stone, cement, or other substance about the base of the tree.

Section 13. Provides that no person shall plant any tree in any highway without first having obtained the permission of the Shade Tree Commission in writing, showing the variety, size and location of such tree.

Section 14. Provides that no person shall pour salt water or any injurious chemical upon a public highway in such a manner as to injure any tree planted or growing thereon.

Section 15. Provides that every person or corporation having any wire charged with electricity running through a public highway, shall temporarily remove such wire or the electricity therefrom when it shall be necessary, in order to take down or prune any trees growing in such highway, within twenty-four hours after the service upon the owner of said wire, or his agent, of a written notice, signed by two members of the Shade Tree Commission, or its secretary, upon the order of such Commission.

Section 16. Provides that every violation by the same person or corporation of any provision of this ordinance or the continuation of the violation of any of its provisions on any day or days succeeding the first violation thereof, shall constitute an additional violation for each of such succeeding days.

Section 17. Provides that any person or corporation violating any of the provisions of this ordinance shall, upon conviction thereof, be punished as follows: For a first offense such party shall forfeit and pay a fine of not more than fifty dollars; for a second or any subsequent offense, a fine of not more than one hundred dollars, or imprisonment not exceeding sixty days, or both the fine and imprisonment.

IV. SUMMARY.

This discussion has attempted to point out that the deplorable condition of shade trees, in general, is not due wholly to the lack of sufficiently strict laws, but rather to the inadequate knowledge of these laws and the lack of initiative in enforcing them. There is need of one or two public spirited citizens in each community to awaken enthusiasm and keep it alive until results are accomplished. Communities may possess sufficient interest to aid them in securing appropriations to be used in the construction of a road, which for a number of years may be more or less a luxury. But the same interest is seldom shown in enhancing the value of real estate and protecting human life by spending a few dollars in caring for the shade trees. The highway improvement, as the macadamizing of a road or the building of a curb in front of a piece of property, adds value to the property, costs much to keep in repair, and decreases in value each year. On the other hand, shade trees cost comparatively little to establish and become more valuable each year, until in the course of fifty years each tree may be worth two hundred to three hundred dollars. They are invaluable as a setting for an otherwise uninteresting section of roadway.

The air in which city trees live is polluted with dust and smoke, together with gases which impair the healthy action of the leaves; the soil in which they are made to grow is often sterile and commonly covered with a pavement which keeps a great amount of moisture from the roots. These injurious conditions are magnified by the presence of sewers which drain the soil water away as quickly as possible, leaving a most arid condition for the feeding roots. In rural districts, street trees are also likely to be neglected.

The salient points in the preceding pages, and the ones which, if used as a basis for action should insure a better condition of shade trees, are the following:

1. The sources of injury from which shade trees are being injured should be carefully studied.

2. The best local and general methods for protecting and preserving the trees from these sources of injury should be considered and adopted.

3. A live and working civic association should be organized, and at its head should be placed some intelligent, enthusiastic and public-spirited citizen who will see that the work of inspecting and caring for the trees is properly performed.

4. State aid should be solicited, if necessary, in establishing a commission that will frame new ordinances and justly punish all offenders.

This Bulletin sets forth some of the following matters:

Injuries arising from gas escaping in the soil are widespread and may be serious. When the injury is severe there is little hope of saving the trees. In the early stages of such injury it is well to break up the hard surface soil and perhaps to open a ditch in order to accelerate the aeration. Pages 453–454.

The injury from electric currents carried by overhead wires has come to be a subject of considerable importance. The electric currents may injure or kill the trees. Every effort should be taken to safeguard the trees against such injuries. Pages 454–456.

The public and the owners of trees should keep a lookout to see that trees are not injured by careless pruning on the part of linemen. Suggestions are given as to ordinances that may control this evil. Pages 456–458.

Tree owners are warned against persons who may represent themselves as competent to prune trees. Pruners should be employed only when their merits are known, or when they come with reliable recommendations. Pages 459–460.

Attention is called to the injury that arises from various kinds of construction work, carelessness of contractors, and the like, together with suggestions as to remedies. Pages 461–462.

What to do when it is necessary to fill about trees is explained on page 462.

The danger from wind and ice storms may be lessened by the proper choice of kinds of trees, and also by careful pruning and removal of all dead wood. Pages 462–463.

Winter-killing may be avoided in part by proper choice of the kinds of trees. Suggestions are given for treating winter-injured trees. Pages 463–464; 471.

Attention is called to injuries from the bites of horses and from wagon wheels. Remedy lies largely in stimulating public sentiment and in enforcing ordinances. Pages 464–465.

In city streets the root systems are likely to be starved for lack of food and water. Suggestions are made for gratings about trees that will let the water in, and instructions are given for the removal of poor soil and filling in with good soil. Pages 465–467.

Smoke and gas may injure trees. The remedy is to choose trees that are likely to be least affected and also to enforce ordinances. Page 468.

The over-crowding and improper placing of trees results in very bad effects. There should be some general oversight over such matters. Pages 468–469.

Attention is called to the necessity of removing wire labels to avoid injury to trees, and directions are given for bridge-grafting trees that have been injured. Page 469.

Means of providing support for newly planted trees are outlined on pages 469–470.

Various kinds of guards for protecting trees against horses and wagons are described on pages 470–471.

Gratings or grills to be placed around trees in paved streets to allow the water to enter the soil, are described on page 471.

The ways of pruning trees and the objects to be secured in the operation are detailed on pages 472–476.

The protecting and dressing of wounds is described on pages 476–477.

Discussion of "tree surgery," or the dressing of large wounds, injuries, and decayed places, is described on pages 478–480. All decayed parts are carefully removed and the cavities filled with cement.

The bolting and chaining of trees to save weak or broken parts is described on pages 480–483.

The remainder of the Bulletin (pages 483–489) is devoted to a discussion of some of the main points in the municipal control of shade trees. The same ideas may be extended, with necessary modifications, to the rural districts.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE RESIDENTS OF NEW YORK STATE WHO MAY DESIRE THEM.

93 The Cigar-Case-Bearer.
121 Suggestions for planting Shrubbery.
129 How to conduct Field Experiments with Fertilizers, 11 pp.
134 Strawberries under Glass.
135 Forage Crops.
136 Chrysanthemums.
137 Agricultural Extension Work, Sketch of its Origin and Progress.
139 Third Report upon Japanese Plums.
140 Second Report upon Potato Culture.
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AGRICULTURAL EXPERIMENT STATION OF

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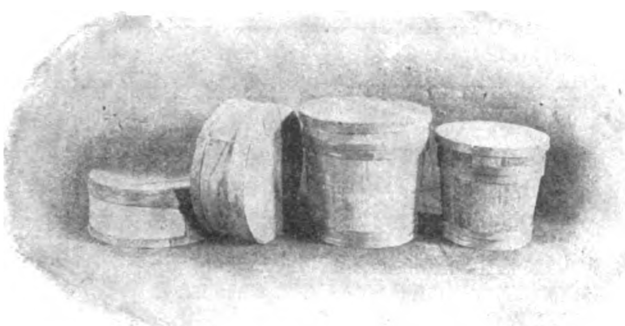
Department of Dairy Industry (Extension Work)

DEFECTS IN AMERICAN CHEDDAR CHEESE



By C. A. Publow

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The regular bulletins of the Station are sent free to persons residing in New York State who request them.

DEFECTS IN AMERICAN CHEDDAR CHEESE.

Causes, Remedies, and How to Prevent Them.

The purpose of this bulletin is to provide a ready reference that will aid New York manufacturers of American cheddar cheese to prevent or remedy the most common defects in their product. In order to understand and to be able intelligently to remedy or prevent defects in cheese, it is necessary to know just what the underlying causes are. If a correct diagnosis is made, then the treatment is usually easy.

I. Defects in Flavor.

A. Acid Flavors.

Indicated by a sour smell and taste.

Cause.

Over-development of acid during the manufacturing period, which is commonly due to one or more of the following:

(1) Ripening the milk too much before adding the rennet.
(2) The use of too much starter.
(3) Failure to firm the curd before removing the whey.

How to prevent.

(1) Have less acid in the milk before adding the rennet. Sour milk should not be accepted from any patron.
(2) Use less starter. Generally one-half per cent. to two per cent. is sufficient.
(3) Add the rennet early enough so that the curd will become firm in the whey before developing the desired amount of acid.

Remedy.

Refer to the treatment explained under remedy for acid texture. (Page 8.)

B. "Off" Flavors.

Flavors that are not clean. When in an advanced stage, cheese so affected are called "stinkers."

Cause.

Undesirable bacteria which gain entrance to the milk or to the curd some time during the manufacturing process, commonly due to:—

(1) Failure of patrons to wash thoroughly and scald all cans and utensils coming in contact with the milk. This is particularly true of cans in which whey is brought from the factory.
(2) Careless milking in unclean places.
(3) Allowing the milk to become exposed after milking, in places where the air is impure.
(4) Keeping the milk at too high temperature.
(5) Using an unclean strainer either at the farm or the cheese factory.
(6) Using utensils in the factory that have not been thoroughly cleaned and scalded.
(7) Using badly flavored starters.
(8) Using impure water for diluting rennet.
(9) Soaking curd in impure water after milling. This causes lack of flavor and later on bad flavor.
(10) Using tainted rennet or salt.
(11) Ripening cheese at temperatures above 60° Fahr.

How to prevent.

By absolute cleanliness in the production and handling of the milk and throughout the whole manufacturing process.
(1) All utensils, especially the milk strainer, should be thoroughly washed with warm water and washing powder, then scalded with live steam.
(2) Milking should be done in clean places, where dust, cobwebs and flies are not found.
(3) Milk should be cooled to at least 60° and better 50° Fahr., immediately after being drawn from the cow.
(4) Tainted milk should not be taken from any patron. If uncertain of the source of tainted milk or curds, use the fermentation test on each patron's milk.
(5) By the use of clean flavored starter.
(6) Impure or bad smelling water should not be used.
(7) Screens should be on the doors and windows to prevent the entrance of flies.
(8) Curds should not be soaked in impure water after milling.

Remedy.

(1) Firm the curd a little more than usual in the whey by raising the temperature.
(2) Develop a little more acid before removing all the whey.

(3) Mill early and expose well to fresh air by stirring for some time immediately after. Excellent results can be secured at this time because each small piece of curd has four freshly cut surfaces which permit the gases and odors to escape.

(4) Increase the amount of salt in extremely bad cases.

(5) Ripen the cheese at low temperatures.

C. FRUITY FLAVORS.

Sweet flavors having an odor like that of ripe fruits, such as pineapple, raspberry, strawberry, etc. To the taste they are not pleasant and somewhat sickening.

Cause.

(1) Bacteria carried into the milk by dirt.

(2) Transporting both milk and whey in the same cans that have not been properly cleansed.

(3) Exposing milk to the air of hog-pens where whey is fed.

How to prevent.

(1) Cans used for delivering milk should not carry whey unless they are emptied and thoroughly cleansed immediately after arriving back from the factory.

(2) All whey should be pasteurized at the factories. This would not only greatly reduce the source of badly flavored milk, but it would eliminate the danger of transmission of tuberculosis through the whey.

(3) The whey tanks should be cleaned and scalded at least twice a week. A steel tank has the following advantages: It is more durable than wood or cement, does not leak, does not absorb the whey, is easily cleaned, and is cheaper in the long run.

(4) Use a clean flavored commercial starter.

Remedy.

(1) Firm the curds a little more in the whey by raising the temperature.

(2) Develop a little more acid.

(3) Air the curd well after milling.

(4) In extreme cases use more salt.

D. BITTER FLAVORS.

Indicated by a bitter taste and a "weedy" odor.

Cause.

(1) Bacteria and yeasts.

(2) Allowing cows to wade in and drink from stagnant pools.

(3) Using rusted milk cans or utensils.
(4) Using old starters that have developed too much acid.
(5) Using milk delivered in cans in which sour whey from dirty tanks is returned.

How to prevent.

(1) Milk should be cooled to at least 60° and better to 50° Fahr. immediately after milking.
(2) Rusted cans or utensils of any kind should not carry milk.
(3) Cows should have good water only.
(4) Clean flavored starters only should be used.

Remedy.

(1) Very little acid should be developed before removing the whey.
(2) Firm the curd more than usual. Heat it higher in the whey and stir it dryer when removing the whey.
(3) Mill early and expose well to fresh air by stirring.
(4) In extreme cases use more salt.

E. FOOD FLAVORS.

Those characteristic of the foods eaten by a cow. A food flavor can be distinguished from one produced by bacteria in that a bacterial flavor usually gets worse as the milk or cheese ages, while a food flavor generally decreases with age.

Cause,

(1) Such foods as turnips, onions, leeks, weeds, garlic, rape, decayed silage and clover.
(2) Exposing milk in an atmosphere where any of these are exposed.
(3) Storing milk in cellars where decayed vegetables are present.

How to prevent.

(1) Foods that impart any objectionable flavor to milk should not be fed or made accessible to the cow.
(2) Use a good commercial starter.

Remedy.

(1) Heat the curd several degrees higher in the whey. The high temperature helps to drive off the volatile flavors.
(2) Air the curd well, especially after milling.
(3) Ripen the cheese at a low temperature.

II. DEFECTS IN TEXTURE AND BODY.

F. DRY TEXTURES.

Cheese that are too firm, mealy, rubbery or corky.

Cause.

Lack of moisture or butter fat or both, produced by
(1) Removing part of the butter fat from the milk.
(2) Too high heating in the whey.
(3) Heating too long.
(4) Too much stirring at the time of removing the whey.
(5) Using too much salt.
(6) Curing cheese in an atmosphere that is too dry or too hot.

A "high cooked" cheese is rubbery or corky; one that has been stirred too dry is mealy or sandy; and one dry from excess of salt tastes salty. This is a convenient way of determining the cause of such defects.

How to prevent.

(1) All the milk-fat should be retained in the cheese as far as possible.
(2) The lower the temperature used for heating and still have the curd firm enough, the better will be the texture of the cheese.
(3) Be absolutely sure of the correctness of thermometers.
(4) Study the moisture content and the amount of stirring and salt required.

Remedy.

(1) Pile dry curds higher.
(2) Keep the air moist by placing hot water in the vat.
(3) Do not mill dry curds early.
(4) A dry curd can be made mellow by soaking in pure cold water after milling, but the cheese will not have a good keeping quality.
(6) Paraffine the cheese as soon as possible.
(7) Ripen the cheese in a cool room where the atmosphere contains at least eighty per cent. moisture.

G. ACID TEXTURES.

These may be either dry or moist, but in either case they are of a mealy or sandy character. They have a sour taste.

Cause.

(1) Ripening the milk too much before adding the rennet.
(2) The development of too much acid during the manufacture especially before the whey is removed.

(3) The great majority of acid or sour cheese are caused, not by the giving of too much acid, but by not having the curd firmed in the whey when the acid has developed.
(4) Using large starters.

How to prevent.

(1) No sour milk or milk containing more than twenty-six hundredths of one per cent acid should be taken from any patron.
(2) Add the rennet early enough so that the curd may be firmed in the whey by the time the acid has developed sufficiently.
(3) Do not use too much starter.
(4) Keep the development of acid under control by controlling the moisture.

Remedy.

When it is absolutely necessary to make sour milk into cheese it should be done in the following manner:

(1) Heat the milk not above 80° Fahr.
(2) Use an extra amount of rennet.
(3) Cut the curd into smaller pieces.
(4) Heat higher. The degree of heat will depend on the rapidity with which the acid is developing. Most fast working curds contract rapidly so the heating can be hurried.
(5) As soon as possible after heating the whey should be run down to the level of the curd. This greatly facilitates stirring and firming of the curd, and if more than one vat is being used, time is saved when the remainder of the whey is to be removed. If by this time the curd is not firm and shows too much acid, a sour cheese can be prevented by,
(6) Removing the whey and putting on pure water at a temperature of 102° Fahr. The amount of water used and the time it is left on will depend on the amount of acid in the curd. In extreme cases it may be necessary to use a second quantity of water. As soon as the curd becomes firmed in the water and the acid reduced to a normal amount, the water should be removed. The curd should then be treated like an ordinary sweet one. This method is not to be confounded with the "soaked curd" process, which is different.
(7) If after milling curds are sour, they can be improved by a washing in pure water at 80° Fahr. This resembles the

"soaked curd" process and as a rule the cheese have not a good keeping quality. However, it is much better than allowing the cheese to sour, and should be used in extreme cases.

Use an extra amount of salt after washing.

H. LOOSE OR OPEN TEXTURE.

Also called soft or weak bodied. These cheese are very soft and full of holes. Such defects are noticed more when found in export cheese, as for that trade a close boring cheese is demanded.

Cause.

(1) Developing too little acid and retaining too much moisture.
(2) Putting curd to press at too high a temperature.
(3) Lack of pressing.
(4) Soaking curd in water after milling.

How to prevent.

(1) Have at least .24 per cent. acid in whey running from the curd after it is piled for cheddaring.
(2) The curd should be cooled to at least 80° Fahr. before pressing. This can be hastened by running cold water around the outside of the vat lining.
(3) Two days pressing is much better than one. A continuous pressure is of more value than a short heavy pressure.
(4) Curd should not be soaked in water.

Remedy.

(1) Open cheese can be closed up considerably by repressing.
(2) Ripen in a cool atmosphere.

I. YEASTY CHEESE.

Indicated in the green cheese by small white pin holes which later enlarge into fish-eye-like slits. The flavor is usually bitter. Colored cheese when affected usually become mottled. A bitter flavor can usually be detected in the milk and curd. The curd may exhibit peculiar characteristics. It is usually difficult to firm in the whey. The acid appears to develop slowly at first, but very fast from the time the whey is started till it is all removed. After milling the curd will become "mushy" if it is at all moist, and the whey running from the curd may show less acid than it did before milling. The curd is usually very

slow to shrink up before salting. In extreme cases the whey tank may boil as though heated by fire.

Cause.

(1) Yeasts. These enter the milk on hay dust and from leaves of trees. They grow and multiply most rapidly when milk is kept at temperatures above 60° Fahr.

(2) Returning sour or unpasteurized whey in milk cans aggravates the trouble.

How to prevent.

(1) Milk should be kept free from dust, and should be cooled to at least 60° Fahr. as soon as milked.

(2) Use a clean commercial starter.

(3) The whey should be pasteurized and the tanks cleaned every day.

(4) If the trouble is already present, the whey tank, all factory utensils and all patrons' milk cans and utensils should be thoroughly cleaned and scalded.

Remedy.

(1) Add the rennet early.

(2) Heat curd in the whey a few degrees higher.

(3) Draw off the whey with as little acid as is practical, but have the curd well firmed first.

(4) Do not pile the curd high unless gas is present.

(5) If gas is present, more acid must be developed at dipping, but the curd should be stirred dryer.

(6) After milling, if the curd tends to become mushy, one-half the salt should be applied. When the curd is well shrunken, apply the other half.

J. GASSY CHEESE.

Indicated by the presence of pin-holes. They usually have a bad flavor, are spongy, and the curd may float on the whey in the early stage of manufacture.

Cause.

(1) Gassy milk produced by bacteria which are carried in by dirt.

(2) Gassy starters.

How to prevent.

(1) Gassy milk should not be accepted from any patron.

(2) Gassy starters should not be used.

Remedy.

(1) If it is known that the milk is gassy, use a safe amount of clean commercial starter.

(2) Ripen the milk a trifle more before adding the rennet.

(3) After cutting, stir the curd till whey around it shows at least .15 per cent. acid before heating.

(4) Heat slowly. Take from thirty minutes to one hour.

(5) Care should be taken to not have the curd too firm in the whey before the acid starts. An acidimeter is a valuable guide at this time.

(6) A little more acid should be allowed to develop before removing the whey. About .32 per cent. after the whey is all off is sufficient.

(7) Should the curd float, remove enough whey to bring the curd to the bottom of the vat.

(8) Pile gassy curds before and after milling.

(9) After milling, the curd should be thoroughly stirred and aired before piling. The pressure causes the small pieces to become very thin. After the piling and airing have been repeated a few times at intervals of fifteen to twenty minutes, the gases should have nearly all escaped. The pin-holes will then have become flattened and present a "dead" appearance.

(10) The whey running from the curd at this time should show 1.2 per cent acid.

(11) Cool curd well before hooping.

(12) Press for two days if possible.

(13) Ripen in a cool place.

K. GREASY TEXTURE.

Indicated by free butter located in mechanical holes in the cheese. The cheese surfaces are usually greasy. This condition is most common in the spring time.

Cause.

(1) Allowing milk to become too old before manufacturing. In factories that do not take milk on Sunday the trouble is always greatest on Monday.

(2) Heating milk too high or too long before adding rennet.

(3) Handling curd too roughly.

(4) Piling curd too much.

(5) Maturing curd at high temperature.

(6) Using a mill that bruises the curd.
(7) Ripening cheese in hot curing rooms.

How to prevent.

(1) Make up the milk daily
(2) Cut and stir the curd very carefully while soft.
(3) Do not pile curd more than two layers deep.
(4) Do not heat milk or curd too high. Be sure of thermometers.
(5) Use a mill that cuts the curd without squeezing the fat from it. The knives should move against the curd and not the curd against the knives.
(6) Apply the salt soon after milling and mature curd in the salt.
(7) Ripen cheese in a cool room.

Remedy.

(1) Rinse the curd with pure water at 90° Fahr. before salting. Then use a trifle more salt.
(2) Cool curd before hooping.
(3) Use large clean press cloths to insure a good rind formation.
(4) Use sufficient hot water at time of dressing the cheese.

III. DEFECTS IN COLOR.

L. PALE OR ACID CUT COLOR.

This term explains itself.

Cause.

(1) The development of too much acid which bleaches or cuts the color from the curd.
(2) Failure to firm the curd early enough in the whey.
(3) Using large starters.
(4) Using poor color.

How to prevent.

(1) Have the curd firmed in the whey before the acid has developed to more than eighteen one-hundredths of one per cent.
(2) Cheese should be colored to suit the market for which they are intended.

Remedy.

(1) The best place and time to produce a bright even color in the curd is while the whey is being removed. From the time the whey has reached the level of the curd till it is all removed, the curd should be well stirred. The color can be seen to develop rapidly during this handling,

(2) Allow the curd to stand sometime after salting before hooping.

M. MOTTLED COLOR.

An uneven color, most noticeable in colored cheese.

Cause.

(1) An uneven development of acid and moisture in the curd.
(2) Uneven cutting, leading to an uneven contraction of the curd when heated in the whey.
(3) Neglecting to strain the starter when lumpy.
(4) Adding starter after color.
(5) Uneven piling and maturing of curds.
(6) Use of poor color.
(7) Mixing curds from different vats.
(8) Lumpy conditions of the curd at time of removing the whey or when salt is applied.
(9) Adding old curd.
(10) Yeasts. When due to these the mottling increases with the age of the cheese.

How to prevent.

(1) By uniform cutting, heating and stirring. This is facilitated by the use of a five-sixteenth inch perpendicular wire knife, and a five-eighths inch horizontal steel knife.
(2) Each particle of curd should be kept separated from the others while being heated.
(3) Starter should always be strained.
(4) Starter should be added before the color.
(5) Curds from different vats should not be mixed.
(6) Old curd should be placed in the vat about fifteen minutes before the whey is removed.

Remedy.

When curds are badly mottled there is no remedy that will make the color uniform. In some instances the color will become more even as the cheese ages.

N. SEAMY COLOR.

A condition in which the outline of each piece of curd can be easily seen in the cheese. The uniting surfaces are marked by a pale line.

Cause.

(1) Greasy curds, which prevent an even absorption of salt.
(2) Impure salt.

How to prevent.

(1) If curds are very greasy they should be rinsed off with pure water at 90° Fahr. just before salting.

(2) Only high grade salt should be used.

Remedy.

Prevention.

O. RUSTY SPOTS.

Red spots resembling rust, and located usually where two pieces of curd have pressed together.

Most noticeable in white cheese.

Cause.

(1) *Bacillus rudensis*, which gains entrance to the milk or curd.

(2) Unsanitary buildings and surroundings. When whey leaks through the factory floor, the red material formed by these bacteria may develop. It may then be carried into the factory by wind or flies. Once in the factory every utensil used in the manufacturing soon becomes infected and the trouble increases.

How to prevent.

(1) Keep everything used in the factory absolutely clean.

(2) Do not allow the factory floor to leak. Cement floors are most sanitary.

(3) Keep the drain and drain pipes clean.

(4) Use screen doors and windows during fly time.

Remedy.

(1) The only way to get rid of this trouble is by a thorough cleaning and disinfecting of the factory surroundings and all utensils.

(2) The starter, if one is used, should be renewed.

How to clean and disinfect.

(1) Wash all utensils with a brush, hot water, and washing powder, and put them into the large milk vat.

(2) Put a cover over the vat and turn live steam into it.

(3) Steam the utensils for at least one-half hour.

(4) If the drains are dirty, clean them with hot water and washing powder. Then steam them for at least twenty minutes.

(5) If the ground surrounding or under the factory is infected, have it covered with lime or fresh earth

(6) The inside walls, cheese shelves and all wood work should be washed with a hot solution of bichlorid of mercury. This is made by dissolving seven and one-half grains of bichlorid of mercury in one pint of water. Apply this solution with a brush or broom, as *it is a poison*.

IV. DEFECTS IN FINISH.

Anything that detracts from the appearance of a cheese is a defect. As a rule it is a defect due to carelessness on the part of the maker.

P. UNCLEAN SURFACES.

Cause.

(1) Placing cheese on unclean or moulded shelves in the curing room.

(2) Using dirty hoops or handling the cheese with dirty hands.

How to prevent.

(1) Wash the shelves after each shipment of cheese leaves the factory. Use a brush, hot water, and some good washing powder that will remove grease Place them in the sunlight to dry.

(2) Cheese hoops should be clean. So should the hands of the maker.

Q. CRACKED RINDS.

Openings in the side or ends of the cheese. They are unsightly and allow the entrance of moulds, flies, etc.

Cause.

(1) Too much acid.

(2) Greasy curds.

(3) Use of hard press cloths.

(4) Lack of pressing.

(5) Wrinkled bandages.

(6) Too dry an atmosphere in curing room.

How to prevent.

(1) Avoid excess acid. (See remedy for acid texture, p. 8.)

(2) Rinse greasy curds with water at 90° Fahr. before salting.

(3) Press cloths can be softened by soaking in a weak solution of sulphuric acid.

(4) Press cheese longer before dressing.

(5) Curing room atmosphere should register eighty per cent. moisture.

Remedy.

(1) Repress the cheese. If this fails,
(2) Paraffine the cheese.

R. MOULDY SURFACES.

The formation may be of several colors.

Cause.

The growth of moulds is due to
(1) Too much moisture in the air.
(2) Atmosphere too warm.
(3) Not enough circulation of air.
(4) Lack of cleanliness in curing room.

How to prevent.

(1) Curing rooms should be so equipped that the temperature and moisture can be controlled.
(2) Good circulation of air should be provided.
(3) Curing room should be kept clean.

Remedy.

(1) By spraying cheese with ten per cent. formalin.
(2) By burning sulfur, three pounds to one thousand cubic feet of air.
(3) By washing the ceilings, walls, shelves and all wood-work with a hot solution of bichlorid of mercury (*poisonous*) made by dissolving seven and one-half grains in a pint of water, and then washing with clear water.
(4) By whitewashing the walls and ceilings.

V. FACTS A CHEESEMAKER SHOULD REMEMBER.

The finished cheese can be no better than the milk from which it is made.

Every cheesemaker should be familiar with the use of the acidimeter and the fermentation test.

The cheese factory should be a centre of rural dairy education.

The maker should be qualified to teach his patrons.

If the factory building is neatly painted, if the surroundings are tidy, and if the maker himself has a good appearance, it will be easier to induce the patrons to furnish better milk.

It will be of much greater value to both the cheesemaker, the patron and the consumer, if in the future more attention is given to the improvement of quality rather than quantity.

SEPTEMBER, 1908 BULLETIN 258

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Poultry Husbandry

THE MOLTING OF FOWLS

BY JAMES E. RICE, CLARA NIXON AND CLARENCE A. ROGERS.

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THE MOLTING OF FOWLS

In recent years much has been said in print and on the platform about the advisability of attempting to force fowls to shed their feathers early in the season with the hope of inducing them to lay earlier in the winter than they would if allowed to follow their natural habit. The method by which this early molt was said to be secured was by starving the fowls for a few weeks, which would cause egg-production to cease and the feathers to loosen through lack of nourishment. This starvation process was followed by liberal feeding on rich, feather-making and egg-producing rations, which were supposed to force a uniform, rapid and complete early molt and a quick growth of new feathers, followed closely by heavy, early-winter laying. As to the wisdom of the practice, practical poultrymen disagree. Among those who have tried various methods of so-called "forcing the molt," there are many different opinions, both as to the best methods to follow and the value of the results to be obtained. Some few who have tried "forcing the molt" favor the practice; others are equally strong in condemning it.

In all the discussions there appear to be few facts presented, either for or against the plan, that may be considered to be conclusive. Almost no comparative results are available. The experiences cited are isolated cases with single flocks where the results secured may have been due to any one of a large number of contributory causes other than the method of feeding for "forcing the molt." The only data on the subject from the Experiment Stations states that the molt can be hastened by certain methods of feeding.* Furthermore, a careful study of the literature on the subject reveals the fact that little appears to be known about the sequence in plumage and the nature of the molt of the domestic fowl.

With the object in view of securing facts as to the nature and growth of feathers and conditions that govern their development, several series of observations have been made at Cornell, and a feeding experiment undertaken, the methods and results of which are now to be discussed.

For convenience and clearness the subject is presented in two parts:

I. Observations on the development of feathers and the sequence in plumage (By Clara Nixon), pages 20 to 28.

II. Experiments in which an attempt was made to "force the molt." (First half by Frank S. Conger; second half by C. A. Rogers), pages 28 to 65.

* Atwood, Bulletin 83, West Virginia Experiment Station.

PART I. SEQUENCE IN PLUMAGE OF THE DOMESTIC FOWL.

Before undertaking to solve the problem of how to force fowls to molt, it is important to know the nature of the feathers and how they develop.

Where the first chick feathers come from.

While the first body-covering of a chick may or may not be called plumage, it is shed and replaced as if it were plumage. The method of

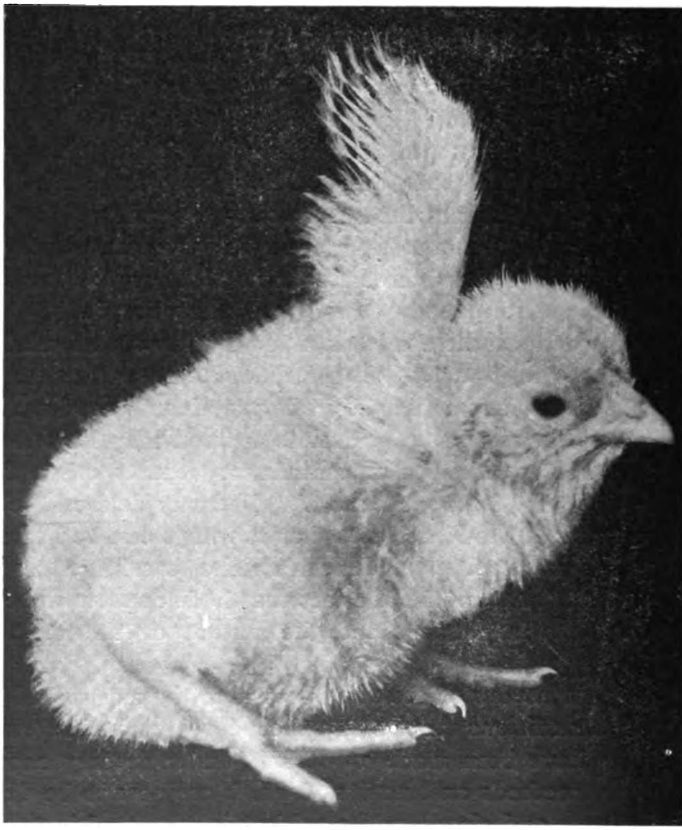

FIG. 1.—*Pin-feathers on the wing of a White Leghorn chick just from the shell. Notice the down tips clinging to the end of the pin-feathers.*

molting, however, is peculiar to the downy coat. The baby chick (in this case a Leghorn) when it comes from the shell, has pin-feathers for flights (Fig. 1). In two or three days it develops pin-feathers that

will become main tail feathers (Fig. 2). The down grows longer and, on certain areas of the body, develops shafts. Within a few days the shafts burst open, allowing the web of the feather to spread out; but the down often clings to the tip of the opened feather (Figs. 1, 2, 3*a*, 4*a*).

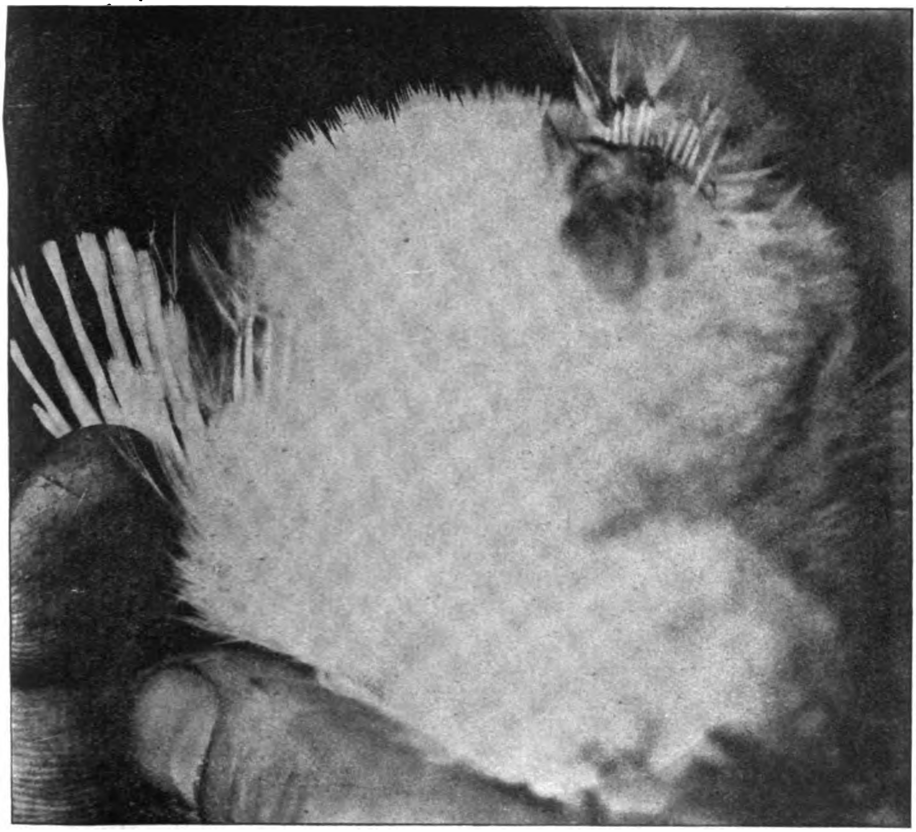

FIG. 2.—*White Leghorn chick four days old, showing the development of tail and wing. Notice the down tips still clinging to a few of both tail and wing feathers, while others have been shed.*

The ragged appearance to be noticed on two or three weeks' old chicks is due to this clinging of the down tips.

Sequence in the growth of feathers.

The first body-feathers to appear are those at the throat, just above the crop (Figs. 5, 6, 7). From this point, a line of feathers extends

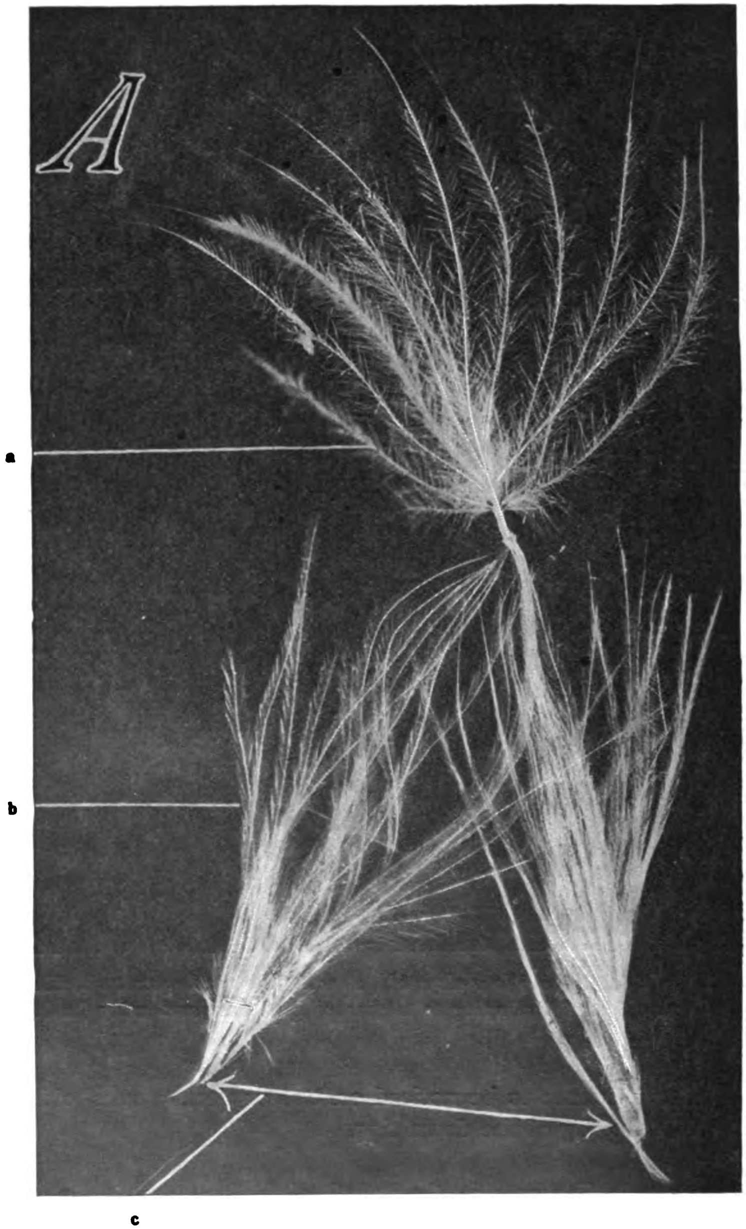

FIG. 3.—*Parts of a fluff feather; a, natal down; b, barbs and barbules; c, base of feather, cut apart.*

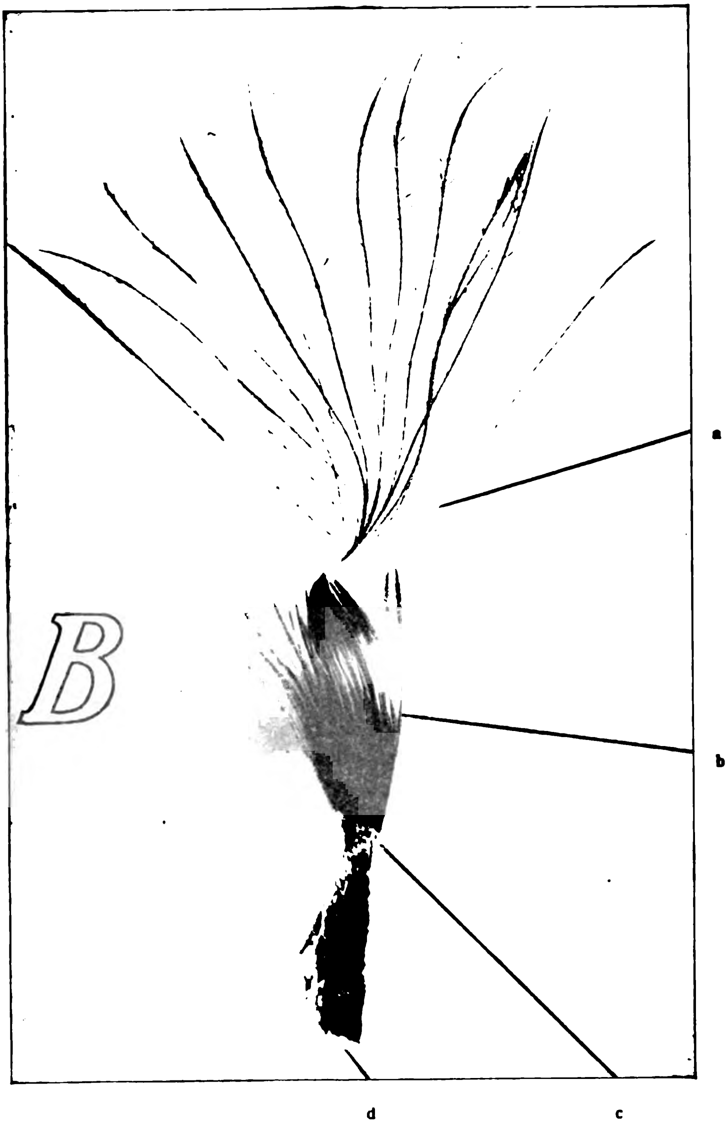

FIG. 4.—*Parts of a shaft feather, a, natal down, b, web of pin-feather, c, sheath; d, shaft.*

down each side of the crop and breast (Figs. 5, and 6). When this line begins to show, a tuft appears on each thigh and a line down the spine (Figs. 5, 6, 7). The feathered areas increase in size as the

chick grows older, so that, at the age of four or five weeks, they have grown together, and the healthy chick looks to be well feathered (Fig. 9). The wings and back are covered, the feathers growing well up the back of the head, and the breast is protected except a small space over the crop. The rear of the body is covered by the flights, the feathers on the thighs, and a tuft near the rear of the keel bone. The legs are encircled by a ring of feathers just above the shank. In a word, the chick's body is protected by its feathers at every vital point (Figs. 5, 6, 7, 9).

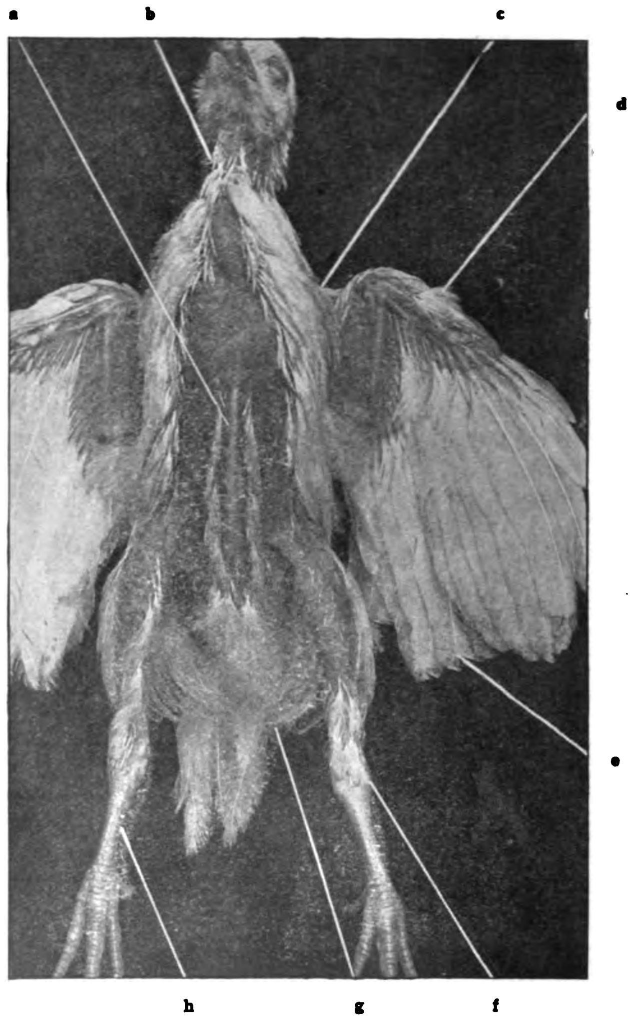

FIG. 5.—*Feather tracts in White Leghorn chick 4 weeks old.—Front view: a, keel; b, throat; c, breast; d, flight-coverts; e, flights; f, leg; g, fluff; h, shank.*

The chick feathers are molted.

It is not generally known whether the chick feathers grow larger with the chick's development or whether they are replaced by new ones; therefore, an effort was made to determine this point. A number of chicks, just from the incubator, were leg-banded and their down stained. These chicks were inspected daily for several weeks,

and, as the feathers appeared, an attempt was made to stain them also. The color took well on the flights and tail feathers, not as well on the body feathers. The first feathers were stained red and those that replaced them were stained black. At the age of eight weeks, all the red feathers in tail and wings had been molted, and at thirteen weeks, all the black feathers had been replaced by white ones. At the times mentioned, the bodies were covered with pin-feathers; but this does not prove that these feathers replaced others which had been shed. This sequence of molts corresponds very closely to the sequence of molts in young wild birds.*

From thirteen weeks to just before maturity (five to six months) the chicks were not

FIG. 6.—*Feather tracts of White Leghorn at 4 weeks.—Side diagonal view: a, breast; b, neck; c, inside of wing; d, flight-coverts; e, back; f, tail; g, thigh.*

* Dwight—"Sequence of Plumage and Molts of the Passerine Birds of New York."

observed to molt. They then shed all their feathers and assumed a more mature dress, the pullets apparently getting their full plumage. They lost their chick voice, developed bright red combs, and, to all appearances, were about to begin to lay. The rotation of this molt was nearly the same as the rotation of feathering in chicks, the oldest feathers being shed first. The wing and tail feathers. which were the first to appear on the chick, were, however, retained until the bird was well along in the molt, and in many cases were not all shed until after the body molt was completed. The time of molting the flights and tail feathers varied in different individuals, but these feathers were usually shed in pairs, one on each wing or corresponding feathers on each side of the tail, as the case might be (Fig, 12 and cover cut). The first tail feath-

FIG. 7.—*Feather tracts in chick of White Leghorn at 4 weeks.—Side view: a, keel; b, breast; c, neck; d, back; e, tail; f, leg.*

ers to be shed were usually the middle pair; the first wing feathers to be molted were commonly the last primary or first secondary on each wing, counting from the tip. The last feathers to be replaced were the ones on the inside of the wing just above the primaries and secondaries, a small tuft on the body just in front of the thigh, and the flight coverts (See cover cut, and Figs. 5, 6, 7, 12).

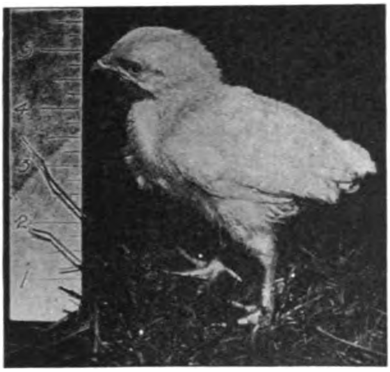

FIG. 8.—*Feathering at different ages. Tail and wings well out at 19 days.*

The molting of pullets.

The pullets appeared to undergo this molt whether they laid or not. After the pullets began to lay, they seemed to shed no more feathers so long as they continued in production. When they ceased to lay, many of them began to molt. In some cases the molt was complete, extending to the flights and the tail; in others it went no farther than the body feathers, while, in still others, it included only a few feathers on different parts of the body.

In former experiments conducted at this Station (Bulletin 249) the pullets beginning production before September first, nearly always molted the entire plumage in the fall. The number of eggs laid before molting did not appear to influence the completeness of the molt. One pullet laid thirty eggs and molted completely; another laid one egg and molted just as completely. Some of the pullets which began to lay at a later date, continued to lay throughout the winter and spring, not molting until the following regular molting season. One of these laid 230 eggs between molts—about 58 per cent production for the entire time—thirteen months and six days.*

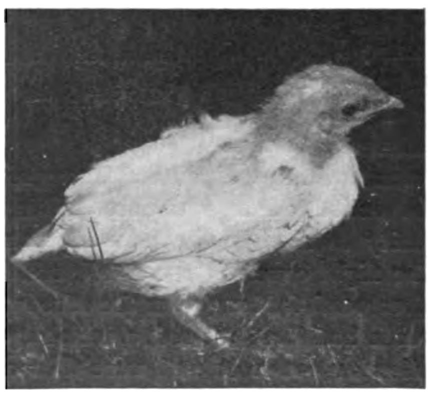

FIG. 9.—*Body well covered with feathers at 34 days.*

* The pullet molts are more fully discussed in bulletin No. 249 of the Cornell Experiment Station.

Time and sequence of the mature molt.

The first mature molt comes at the end of the first year of laying. It seems to be a necessary renewal of the worn-out plumage. Feathers, like clothes, wear out (Fig. 11).

In the mature molt, it was found that the rotation followed closely that of the pre-nuptial* molt before egg production commenced,—the oldest feathers being shed first. The mature molt seldom began while the hen was laying. Quite a few feathers might be shed earlier in the season, and during production; but, in most cases, the shedding of feathers ceased for a week or two,—often for a much longer period, then the entire plumage was renewed. For convenience, this latter part of the molt is termed the "general molt." During this molt, some hens shed only a few feathers at a time in the different feather tracts, looking well clothed throughout the molt, while others shed almost the entire plumage at once. This quick shedding gave a good opportunity to observe the feather tracts on a hen (Cover cut and Fig. 12). The flight coverts, (the small, stiff feathers on the finger of the wing), often persisted long after the other plumage was molted. These feathers, which had been colored, were observed on several hens as late as April following the molt, and were then apparently as firmly fixed as ever.

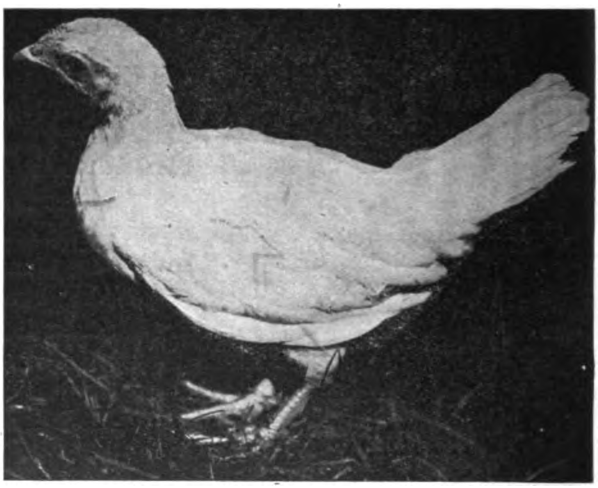

FIG. 10.—*Completely plumed with chick feathers at 54 days.*

PART II. AN ATTEMPT TO FORCE THE MOLT.

On August 11, 1906, we arranged 232 Single Comb White Leghorn fowls in six pens for the molting experiment. The details of housing, feeding and management may be stated, in order that the reader may have a complete mental picture of the experiments.

* Dwight —"Sequence in Plumage of Passerine Birds."

Housing.

In pens 5 and 8 there were respectively 40 and 38 three-year-old hens; in pens 19 and 22, there were 40 and 42 two-year-old hens; and in pens 24 and 25, there were 34 one-year-old hens each. The flocks in each set of pens were divided as near equally as possible in regard to weight and vigor. The experiment was continued until November 8, 1907, covering a period of 455 days. This time was divided into fifteen 28 day periods

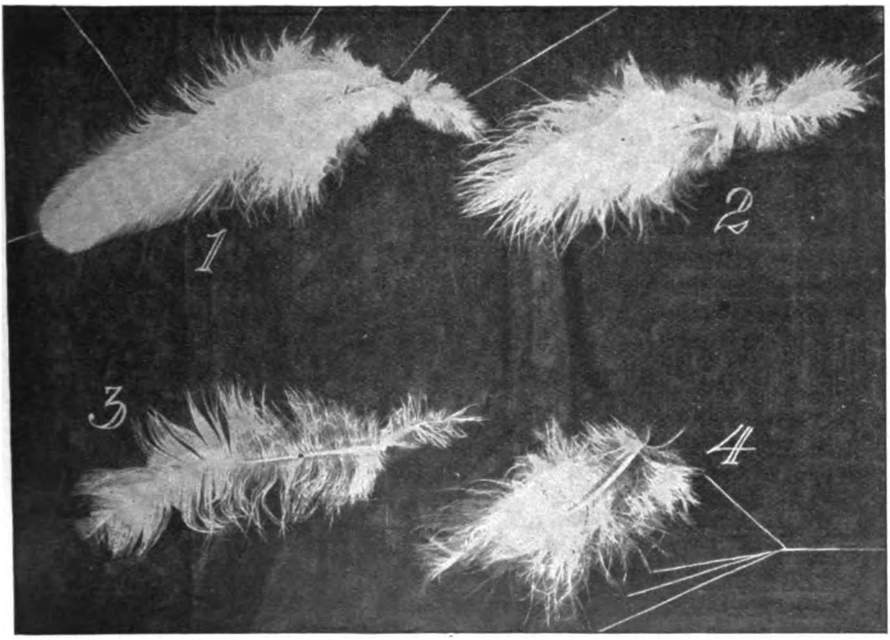

FIG. 11.—*New and old feathers.* 1, *new back-feather;* 2, *new fluff-feather;* 3, *worn back-feather;* 4, *worn fluff-feather;* *a*, *tip;* *b*, *web;* *c*, *down;* *d*, *shaft;* *e*, *bract.*

and one 35 day period. Males were kept in pens 24 and 25 throughout the entire experiment, and in the other pens during the winter and early summer only. The hens in pens 24 and 25 (one-year-olds) were trap-nested, the records having been begun January 24, 1906.

Flocks 5 and 8 were kept in the same house. Each of these pens contained 2.25 square feet floor space; .13 square feet cloth or glass surface; and 17.5 cubic feet air space per hen. Flocks 19 and 22 were in the same house in similar pens each containing 2 square feet floor space and 1.2 square feet cloth or glass surface per fowl, Pen 19 having 18.2 cubic feet, and Pen 22, 15.4 cubic feet, of air space per fowl, in the roosting room. (Computed on a basis of the number of hens in

the pens when the experiment was begun.) Each pen had, also, in the scratching shed, 2.75 square feet floor space, .6 square feet cloth or glass surface, and 23 cubic feet air space per fowl. Flocks 24 and 25 each had 4.4 square feet floor space, .29 square feet cloth or glass surface, and 37.6 cubic feet air space per hen. The three-year-old hens (pens 5 and 8) and two-year-old hens (pens 19 and 22) were in houses having double boarded, solid walls. The one-year-old hens (pens 24 and 25) were in a double walled house with dead air space stuffed with straw and with a straw loft. It was exceptionally warm, and so close as to be objectionable.

An effort was made to provide all flocks with fresh air by having the windows open much of the time by day, and cloth frames in the windows during the night.

While the house conditions were slightly different between the pens of the three-year-olds (pens 5 and 8), two-year-olds (pens 19 and 22), and one-year-olds (pens 24 and 25), the pens occupied by the fowls of the same age were similar.

FIG. 12.—*Heavy molt. A White Leghorn hen in full molt. Note the feather tracts as compared to figs. 5, 6, 7.*

Flocks 5 and 8 (three-year-olds) were allowed to run in similar yards with limited grass forage. The other flocks had constant access when out of doors to alfalfa pasturage. All flocks were confined to the pens during November, December, January and February.

Methods of feeding.

The attempt to force the molt was by means of restricting the amount of food, rather than by changing the quality of the ration. The starvation period lasted for four weeks. In the first week, the amount of food was gradually reduced to one-half the usual quantity. In the following two weeks, about one-third rations were fed, which were gradually increased in the fourth week till, at its close the flocks which had been starved were given all they would eat.

Three flocks were fed in the usual way and the other three flocks were given a similar ration, but in limited quantity. The three flocks that were given the

restricted ration will be termed the "starved" flocks and the three that were fed in the usual way will be called the "fed" flocks.

The flocks were so arranged as to compare the effect of the so-called "forcing of the molt" on fowls of three different ages. Flocks 5 (starved) and 8 (fed) were three years old: flocks 19 (starved) and 22 (fed) were two years old: and flocks 24 (starved) and 25 (fed) were one year old.

Each flock received the same kind of mixed grains, which were thrown into the litter every morning and evening. This mixture was varied from time to time throughout the experiment for periods beginning with dates as follows:

August 11, 1906—cracked corn, 10lb; wheat, 6lb; oats, 8lb.
January 12, 1907—corn, 3lb; wheat, 3lb; oats, 4lb; buckwheat, 2lb.
March 30, 1907—cracked corn, 3lb; wheat, 3lb; oats, 2lb.
June 29, 1907—corn, 15lb; wheat, 9lb; oats, 12lb.
August 24, 1907—cracked corn, 10lb; wheat, 6lb; oats, 4lb.

The ground grains and meat mixture was hopper-fed to flocks 19 and 22, the hoppers being open at all times. The same ground grain and meat mixture was fed to flocks 5 and 8 and 24 and 25 in a moist condition, water and occasionally vegetable soup being used to moisten it. This ground grain and meat mixture was varied from time to time for periods beginning with dates as follows:

August 11, 1906—corn meal, 4lb; wheat bran, 2lb; wheat middlings, 3lb; oil meal, 1lb; alfalfa meal, 1lb; meat scraps, 1lb.
January 25, 1907—corn meal, 4lb; wheat bran, 2lb; wheat middlings, 3lb; oil meal, 1lb; alfalfa meal, 1lb; meat scraps, 2lb.
February 15, 1907—corn meal, 8lb; wheat bran, 2lb; wheat middlings. 2lb; oil meal, 1lb; alfalfa meal, 1lb; meat scraps, 2lb.
March 23, 1907—corn meal, 5lb; wheat bran, 3lb; wheat middlings, 4lb; oil meal, 1lb; alfalfa meal, ½lb; meat scraps, 4lb.

Mangel beets were fed in limited quantity during the winter months, as was also green cut bone.

Grit and oyster shells were always accessible.

Observations and records.

All of the fowls were weighed at the beginning of the experiment and at the end of important periods in the experiment. Observations were made of the fertility and hatching-power of eggs from the trap-nested pens. The conditions of production, and broodiness and general health were observed in all the pens throughout the experiment.

Molting observations were made of each hen every week throughout the molting season, beginning August 11th, 1906, and continuing until the hens had all completed their molt, on January 26th, 1907.

To aid in observing the molt, and to detect quickly fowls that escaped from the pens, the hens (all White Leghorns) were dipped in Diamond Dyes (Fig. 13). The feathers took the stain well, thus making distinctly visible the new white plumage that later appeared. In order to tabulate the observations of the various stages of the molt they were designated as follows, as shown in the tables:

(1) N. M.=Not Molting—The hen is shedding no feathers.
(2) F=Few Feathers—Only a few feathers are coming out; sometimes at the throat, but oftener a few in each section.
(3) H=Heavy Molt—The energy of the hen is devoted to producing a new coat, and large numbers of pin-feathers are present.

(4) A=Advanced Molt—The web of the feathers is spread out, but the plumage is still immature. The sheath is often not all removed from the individual feather, the web is uneven, the down is not fluffy, and a white feather is likely to look yellowish.
(5) N. N.=Nearly New—The hen is nearly new feathered, but has a few old feathers or pin-feathers in some section or sections.
(6) N.=New=Complete Molt. The molt is fully completed, and the feathers matured.

It will be seen that the total consumption of food, including grit and shell for the entire experiment, did not vary greatly among the different flocks (Tables I, II; Figs. 16, 17). In every case the fed flocks consumed more food during the experiment than the starved flocks of the same age. This difference occurred mainly during the starvation period. The same general comparisons are true when the total amount of food is compared, not including grit and shell, or when the actual food nutrients is compared (Tables I and II; Figs. 16 and 17).

FIG. 13.—*Dipping the fowls in Diamond Dyes to observe the molt. Orange, violet, carmine and green were the most enduring colors.*

The largest quantity of food, including shell and grit, was consumed by the youngest fowls. For instance, the two flocks of three-year-old fowls together consumed at the rate of 15,996 pounds, the two-year-olds 16,998 pounds, and the one-year-olds, 19,143 pounds per hundred fowls during the experiment.

The total quantity of food consumed during the experiment was greatest with the flocks that laid the most eggs (Tables I and II; Figs. 16 and 17). The amount of grit and shell eaten in proportion to the other food consumed in the six pens varied considerably among the different pens, the lowest amount being (Pen 8), 11.3 lbs, and the highest (Pen 24), 20.8 lbs grain, to one of grit and shell, showing the large amount of grit and shell material required by fowls in laying condition.

The nutritive ratio, based on the total amount of digestible nutrients consumed during the experiment by the six pens, varies but slightly between the flocks of different ages, and even less between flocks of the same age (Table II). All the rations may be said to be well balanced, so far as our limited knowledge of what constitutes a properly balanced ration for egg production may determine.

Influence of method of feeding on gain or loss in weight.

The average weight in the six flocks under observation when the experiment began (August 11, 1906) was 3.5 pounds. At the close of the starving period (the first four weeks of the experiment) it was 3.3 pounds. This loss was due entirely to the starved flocks, these hens having lost an average of .42 pounds each. while the fed hens gained an average of .08 pounds each. At the end of the molt, January 12, 1907, the starved hens averaged 3.66 pounds and the fed hens 3.74 pounds, a gain above the first weight by the starved fowls of .16 pounds each, and by the fed of .25 pounds each, or .2 pounds average of all flocks. In every case, in all the flocks, the hens lost in weight during the process of molt; but many regained the lost flesh before the molt was completed (Table III and Figs. 16 and 17).

It will be observed that the two three-year-old flocks lost in the first four weeks .22 of a pound; the two two-year-olds, .09 of a pound; and the two one-year-olds, .12 of a pound. The starved hens, it will be noted, lost on an average nearly one-half pound each, or about one-seventh of their entire weight, equal to about 16%. This loss in weight, was, however, quickly regained in the following five periods; *i.e.*, by about the middle of January, when all the flocks increased their weight to the normal or above, preparatory to the period of increased egg-production.

Uniformity of molt and time of completion of molt of the starved and fed flocks.

By examining Table IV it will be seen that about one-half of the fowls in all of the flocks were beginning to molt in the first period, beginning August 11th, and that on September 29th, 1907, about 90% of the starved hens and 78.8% of the fed hens were molting. By October 27 the percentage of molting was about equal and continued on this equality to the end of the molt.

In regard to new plumage, on October 27, only 6.3% of the starved hens and 5.9% of the fed hens were completely refeathered. November 25th only 34.4% of the starved, and 62.2% of the fed hens were

TABLE I.—TOTAL CONSUMPTION OF FOOD PER 100 HENS IN A PERIOD OF 1 YEAR AND 90 DAYS (SEE ALSO FIG. 9).

	Pen 5 3 yrs. old Starved	Pen 8 3 yrs. old Fed	Pen 19 2 yrs. old Starved	Pen 22 2 yrs. old Fed	Pen 24 1 yr. old Starved	Pen 25 1 yr. old Fed
Corn	2041.8	2124.1	1783.7	1958.8	2235.4	2304.2
Wheat	1692.4	1769.7	1467.6	1619.2	1809.5	1893.9
Oats	1297.4	1337.0	1145.1	1309.9	1365.0	1531.9
Buckwheat	152.5	151.8	140.9	137.5	159.2	179.1
Corn meal	536.2	555.9	1070.6	1012.0	576.3	576.7
Wheat bran	327.0	338.2	617.5	618.8	354.6	360.1
Wheat middlings	451.7	468.5	862.3	857.5	498.0	498.0
Oil meal	86.1	88.5	199.5	176.3	92.2	99.1
Alfalfa meal	103.9	117.7	177.6	195.1	113.9	108.5
Meat scrap	394.7	440.6	745.3	682.9	385.4	394.7
Green food	150.2	154.9	134.4	159.5	220.2	193.9
Green cut bone	24.7	25.7	26.0	28.3	29.7	27.9
Shell	285.2	322.2	263.7	272.4	373.0	313.1
Grit	214.6	342.9	187.6	148.8	285.5	165.0
Total Food, including grit and shell	**7758.4**	**8237.7**	**8821.8**	**9177.0**	**8497.9**	**8646.1**

TABLE I (*Continued*).—CONSUMPTION OF FOOD PER 100 HENS DURING A PERIOD OF 1 YEAR AND 90 DAYS, RE-ARRANGED IN GROUPS FOR COMPARISON.

	Pen 5 3 yrs. old Starved	Pen 8 3 yrs. old Fed	Pen 19 2 yrs. old Starved	Pen 22 2 yrs. old Fed	Pen 24 1 yr. old Starved	Pen 25 1 yr. old Fed
Total food, not including shell and grit	7258.6	7572.6	8370.5	8755.8	7839.4	8168.0
Total whole grains	5184.1	5382.6	4537.3	5025.4	5569.1	5909.1
Total ground grains	1504.9	1568.8	2927.5	2859.7	1635.0	1642.4
Total whole and ground grains	6689.0	6951.4	7464.8	7885.1	7204.1	7551.5
Total beef scrap	394.7	440.6	745.3	682.9	385.4	394.7
Total shell and grit	499.8	665.1	451.3	421.2	658.5	478.1
% of whole grain to entire ration, exclusive of green food, grit and shell	72.92	72.55	55.07	58.45	73.07	74.10
% of ground grain to whole ration, exclusive of green food, grit and shell	21.16	21.13	35.53	33.26	21.45	20.59
% of meat scrap to whole ration, exclusive of green food, grit and shell	5.55	5.93	9.05	7.94	5.05	4.94
% of grit and shell to whole ration, exclusive of green food	6.56	8.22	5.07	4.66	7.95	5.65
Proportion of grit and shell to other food consumed, expressed in proportion of one pound of the former	14.5	11.3	18.5	20.8	11.9	17.00

Average of all pens, 19 pounds grain to one pound grit and shell.

TABLE II.—TOTAL AMOUNT OF FOOD NUTRIENTS CONSUMED PER 100 HENS.

	Pen 5 3 yrs. old Starved	Pen 8 3 yrs. old Fed	Pen 19 2 yrs. old Starved	Pen 22 2 yrs. old Fed	Pen 24 1 yr. old Starved	Pen 25 1 yr. old Fed
Dry matter	6339.2	6719.2	7338.2	7672.3	6812.4	7116.4
Ash (including grit and shell)	680.84	854.28	685.47	662.05	852.47	680.29
Protein	909.7	965.6	1254.9	1240.6	955.0	993.4
Carbo-hydrates	4039.9	3900.2	4389.0	4647.8	4288.5	4553.7
Fat	282.5	297.6	380.4	367.1	298.5	312.8
Nutritive Ratio	1–5.13	1–4.73	1–4.17	1–4.41	1–5.11	1–5.27
No. lb. dry matter consumed per lb. live weight. Computed at average wt. of average fowl per year	16.99	17.45	22.33	22.69	20.33	20.99
No. lb. dry matter consumed per lb. eggs produced. Computed at 24 oz. to the dozen	5.72	4.89	4.94	4.92	4.27	4.10

TABLE III.—

Weight of Starved and Fed Fowls at Stated Periods. (See also Figs. 16, 17).

	Periods	Starved				Fed			
		5 3 year olds	19 2 year olds	24 1 year olds	Ave.	8 3 year olds	22 2 year olds	25 1 year olds	Ave.
1	Aug. 11–Sep. 7..	3.91	3.16	3.44	3.503	4.02	3.23	3.49	3.58
2	Sep. 8–Oct. 5....	3.46	2.82	3.00	3.093	4.02	3.39	3.49	3.633
3	Oct. 6–Nov. 3...	.....	.....	.....	.....	.....	.....	.....	.....
4	Nov. 4–Dec. 1...	3.52	3.17	3.10	3.296	3.57	2.93	3.07	3.19
5	Dec. 2–Dec. 29..	3.47	3.12	3.26	3.283	3.59	3.01	3.17	3.26
6	Dec. 30–Jan. 26..	3.74	3.68	3.57	3.663	3.98	3.76	3.58	3.773
7	Jan. 27–Feb. 22..	.....	.....	.....	.....	.....	.....	.....	.....
8	Feb. 23–Mar. 22.	.....	.....	.....	.....	.....	.....	.....	.....
9	Mar. 23–Apr. 19.	4.24	3.76	3.60	3.866	4.24	3.74	3.59	3.856
10	Apr. 20–May 17..	.....	.....	.....	.....	.....	.....	.....	.....
11	May 18–June 14.	.....	.....	.....	.....	.....	.....	.....	.....
12	June 15–July 12.	.....	.....	.....	.....	.....	.....	.....	.....
13	July 13–Aug. 9..	3.97	3.39	3.45	3.603	3.91	3.62	3.45	3.66
14	Aug. 10–Sep. 6..	.....	.....	.....	.....	.....	.....	.....	.....
15	Sep. 7–Oct. 4....	.....	.....	.....	.....	.....	.....	.....	.....
16	Oct. 5–Nov. 8...	3.53	3.18	3.39	3.366	3.48	3.36	3.26	3.366
	Average weights...	3.73	3.286	3.351	3.46	5.851	3.38	3.389	3.54

Average Weights of Fowls of Three Different Ages at Stated Periods.

	Periods	Three Years Old			Two Years Old			One Year Old		
		5 Starved	8 Fed	Ave.	19 Starved	22 Fed	Ave.	24 Starved	25 Fed	Ave.
1	Aug. 11–Sep. 7..	3.91	4.02	3.96	3.16	3.23	3.19	3.44	3.49	3.46
2	Sep. 8–Oct. 5....	3.46	4.02	3.74	2.82	3.39	3.10	3.00	3.49	3.24
3	Oct. 6–Nov. 3...	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	Nov. 4–Dec. 1...	3.52	3.57	3.54	3.17	2.93	3.05	3.10	3.07	3.08
5	Dec. 2–Dec. 29..	3.47	3.59	3.53	3.12	3.01	3.06	3.26	3.17	3.21
6	Dec. 30–Jan. 26..	3.74	3.98	3.86	3.68	3.76	3.72	3.57	3.58	3.57
7	Jan. 27–Feb. 22..	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	Feb. 23–Mar. 22.	.....	.....	.....	.....	.....	.....	.....	.....	.....
9	Mar. 23–Apr. 19.	4.24	4.24	4.24	3.76	3.74	3.75	3.60	3.59	3.59
10	Apr. 20–May 17..	.....	.....	.....	.....	.....	.....	.....	.....	.....
11	May 18–June 14.	.....	.....	.....	.....	.....	.....	.....	.....	.....
12	June 15–July 12.	.....	.....	.....	.....	.....	.....	.....	.....	.....
13	July 13–Aug. 9..	3.97	3.91	3.94	3.39	3.62	3.50	3.45	3.45	3.45
14	Aug. 10–Sep. 6..	.....	.....	.....	.....	.....	.....	.....	.....	.....
15	Sep. 7–Oct. 4....	.....	.....	.....	.....	.....	.....	.....	.....	.....
16	Oct. 5–Nov. 8...	3.53	3.48	3.50	3.18	3.36	3.27	3.39	3.26	3.32
	Average weights...	3.73	3.851	3.79	3.286	3.38	3.333	3.351	3.389	3.369

completely renewed, while as late as December 30, there still remained 16.6% of the starved and 15.5% of the fed hens which were not in their new coats.

On the whole it may be said that from August 25 to October 23 the starved flocks showed a larger percentage of individuals molting. After that time, there was more molting among the fed hens, though both flocks completed the molt at about the same time. The molt of the starved flocks was more uniform, and the hens appeared in better physical condition at the end of the molt, than the fed hens. This may have been due to the fact that the fed hens had laid more eggs. After all flocks had resumed production there was little, if any, difference in their condition or appearance (Tables IV, V and VI and Figs. 14, 15, 18).

Time required to grow feathers.

It is variously asserted that the time required for the growth of a body feather on a healthy fowl is approximately forty-two days, while the time needed to develop the tail is somewhat longer. This refers to plucked feathers. The usual molting period of a hen cannot, however, be accurately calculated from this estimate. In the experiment under consideration, the average time of complete molting in the six flocks, containing at the end of the molting season 215 hens, was ninety-five days (Tables IV, V and VI). The average time required to complete the molt of the three-year-olds was nearly 104 days; of the two-year-olds, about 101 days, and of the one-year-olds, 82 days. The starved one-year-olds averaged to molt more quickly by 33 days, than did the fed; the starved two-year-olds were little affected; while the starved three-year-olds averaged 20 days longer in molting than did the fed birds. The average time required to complete the molt of the three starved flocks was 93.8 days; of the three fed flocks 97.4 days. (Table IV).

All this would indicate that the molting process continues much longer than is usually supposed, and that there is considerable variation in the time of beginning the molt between different individuals, and between flocks of different ages, also a wide variation in the length of time it requires individuals to complete the molt. One is further impressed with the fact, that, so far as this experiment is concerned, the method of feeding did not materially alter the normal conditions of molting, except with the one-year-old fowls.

Following are opinions of competent authorities on the subject of feather development.

"I have found that the longer before the molting season you molt the

fowl, the longer it takes the feathers to grow in again. Have seen a fowl picked in May and be in full feather in August, the small feathers growing first, then the wing and then tail feathers, and then I have seen others picked and all the feathers but the tail come in and that did not come in until the last of October. We often molt the crest of the Polish and they would come in perfect in three months. And then I have seen a Light Brahma molted in August and in four weeks have a perfect plumage."—*M. M. Davenport.*

"When feathers get broken, if removed, six weeks will fully replace. If a tail gets smashed, remove all, in four weeks it will look well, in six weeks be perfect. When in full molt and all feathers are growing at same time, 8 weeks is as short time as perfection will be reached. But single, broken feathers, 5 to 6 weeks will replace them. In preparing for exhibition, if five weeks before, all broken feathers and mate feathers to broken ones are removed they will come out even and look fine."—*I. K. Felch.*

("Mate feathers" are feathers in similar position in the same section on opposite sides of the fowl.)

"During the fall and early winter when the weather is favorable for their growth, a main tail, sickle, primary or secondary feather will mature in six weeks. The hackle and saddle require at least eight weeks."—*D. J. Lambert.*

"I have pulled the tails of Cochin females and have had them grow so that the points

FIG. 14.—*Feather accumulations on droppings boards in 14 days. Photograph taken 48 days after experiment was begun. 3 year olds, Pen 5, (starved;) Pen 8, (fed.) Practically no difference can be observed in the number of feathers shed by the different pens whether the comparison be made between flocks of different ages or between flocks differently fed.*

FIG. 15.—*Feathers accumulated in the litter in 14 days. Photograph taken 48 days after the experiment began. Little, if any, difference in the number of feathers shed by the different flocks can be observed. Pen 19, (starved); Pen 22, (fed).*

of the tail feathers would show about an inch beyond the cushion in twenty-one days, and some have taken twenty-seven days to grow an equal length. Cochin Bantams will grow their main tail feathers so as to protrude beyond the cushion feathers in three weeks. Mr. Wm. McNeail of Canada, told me that it took a Hamburg over six weeks to grow decent length sickles, but of this I cannot absolutely say."—*T. F.McGrew.*

"About three months, as I recall, beforehand, I chanced to take a bird with a tail so badly broken that I pulled every main and covert as well as the sickle feathers. They came in nicely and at the time of the show were two-thirds mature."—*Mrs. Geo. E. Monroe.*

The quantity of food consumed increases during egg-production.

That the number of eggs produced bears a close relationship to the amount of food consumed, is strikingly shown in Fig. 16, A and B, where it will be seen that the hens which laid the largest number of eggs consumed the most food. Periods of large egg-production always appear to be periods of increased food consumption and vice versa.

An increase in food consumption slightly precedes and over-laps the period of egg-production.

It will be noticed that the increase in the amount of food consumed precedes, by a few weeks, the increase in production, showing that the fowl fortifies her body by storing up the nourishment from which to produce eggs (Fig. 16, A, B and C).

Weight of hen is greatest preceding heaviest egg-production.

A glance at the plotted curves, Fig. 16, comparing (B), the weight of the fowls during each period, and (C) the per cent egg-production for each period will indicate how uniformly the curve showing increase and decrease in production follows the curve of increase and decrease in weight.

The youngest fowls ate the most food and laid the most eggs.

A comparison of the amount of food consumed, the eggs laid, and the weight of flocks of different ages (Fig. 16, A, B and C) shows that the youngest fowls ate the most food and produced the largest number of eggs.

The per cent egg-production varies each month, according to the seasons, with remarkable regularity.

This is strikingly illustrated in the plotted curves of production during the 16 periods of 28 days each, for the six flocks of fowls of different

TABLE IV.—COMPARISON OF MOLTING OF 3 STARVED AND 3 FED PENS BY PERIODS OF 7 DAYS.

DATES	Starved: Pens — Number in Pens	Starved: 5 Pens, 3 yrs. old — Per cent molting	Starved: 19 Pens, 2 yrs. old — Per cent just beginning	Starved: 24 Pens, 1 yr. old — Per cent heavy molt	Starved: Per cent advanced molt	Starved: Per cent nearly new	Starved: Per cent new	Fed: Pens — Number in Pens	Fed: 8 Pens, 3 yrs. old — Per cent molting	Fed: 22 Pens, 2 yrs. old — Per cent just beginning	Fed: 25 Pens, 1 yr. old — Per cent heavy molt	Fed: Per cent advanced molt	Fed: Per cent nearly new	Fed: Per cent new
August 11	116	49.1	8.3	37.4	3.4	......	......	116	46.4	10.3	35.2	.9	......	......
" 18	115	52.1	10.2	41.0	4.3	.9	......	112	52.8	10.9	38.3	3.6	......	......
" 25	113	57.2	9.8	46.6	8.0	.8	......	112	54.9	7.9	38.4	7.7	.9	......
September 1	113	70.1	7.0	50.8	9.7	2.6	......	112	58.2	7.9	39.5	8.1	2.7	.9
" 8	114	82.6	6.9	60.9	11.4	3.4	......	111	55.2	9.5	35.1	7.9	2.7	.9
" 15	112	82.5	5.2	60.9	15.0	1.4	......	110	38.4	7.0	24.4	6.0	1.0	......
" 22	111	86.3	3.5	52.5	25.0	5.3	......	110	76.5	9.8	46.0	17.9	2.8	......
" 29	111	90.0	1.7	46.3	31.3	10.7	......	110	78.8	9.8	42.3	21.6	5.1	......
October 6	110	90.9	6.1	35.2	43.4	6.2	......	110	88.5	8.6	51.9	24.6	3.4	......
" 13	110	93.2	9.0	27.4	47.7	9.1	......	110	92.4	5.1	51.6	32.3	3.4	......
" 20	110	96.6	2.0	38.9	52.0	3.9	1.7	110	96.2	1.0	55.0	38.7	1.5	.9
" 27	110	89.3	1.8	45.6	36.7	5.2	6.3	110	89.8	......	52.6	35.3	.9	5.9

November 4	109	83.6	1.0	28.6	44.6	9.4	14.1	109	85.6	1.0	51.2	30.6	2.8	11.8
" 11	109	76.5	1.0	22.4	37.0	16.1	19.6	108	59.2	......	36.5	19.4	3.3	6.0
" 18	109	69.9	......	19.0	27.2	23.7	25.5	108	79.7	......	35.5	36.0	8.2	19.0
" 25	110	61.6	......	15.3	28.8	17.5	34.4	108	68.9	......	23.9	41.2	3.8	26.2
December 2	112	52.4	......	2.6	32.6	17.2	44.4	108	67.2	......	13.3	44.4	9.5	31.2
" 9	111	46.8	......	3.5	25.1	18.2	51.0	107	59.7	......	6.7	43.3	9.7	38.9
" 16	111	26.0	......	.9	25.1	......	73.0	106	40.9	......	......	36.2	4.7	57.8
" 23	......	......	......	......	......	......	......	......	......	......	......	......	......	......
" 30	111	15.6	......	......	14.7	.9	83.4	106	15.4	......	......	14.4	1.0	84.5
January 5	......	......	......	......	......	......	......	......	......	......	......	......	......	......
" 12	111	2.9	......	......	2.9	......	97.1	106	5.0	......	......	5.0	......	94.9
" 19	......	......	......	......	......	......	......	......	......	......	......	......	......	......
" 26	......	......	......	......	......	......	......	......	......	......	......	......	......	......

TABLE V.—COMPARISON OF WEIGHTS AND DAYS MOLTING BY DIFFERENT METHODS OF FEEDING.

Three starved flocks	Average days molting	Average weight at beginning of molt	Average weight at close of molt	Per cent which gained in weight	Per cent which lost in weight	Average loss in weight at completion of molt	Average gain in weight at completion of molt	Average weight at close of first four weeks	Average *loss* at end of first four weeks	Average *gain* at end of first four weeks	Average weight Jan. 12, 1907	Average *loss* in weight from Aug. 11, 1906	Average *gain* in weight from Aug. 11, 1906
	da.	lb	lb	%	%	lb	lb	lb	lb	lb	lb	lb	lb
Pen 5 (3 year olds).........	113.6	3.91	3.49	8.1	81.0	.42	......	3.44	.47	......	3.73	.18	....
Pen 19 (2 year olds)........	102.4	3.15	3.32	63.1	34.1	....	.17	2.86	.29	......	3.68	......	.53
Pen 24 (1 year olds)........	65.5	3.46	3.30	34.3	43.7	.16	......	2.94	.52	......	3.57	......	.11
Average of 3 starved flocks	**93.8**	**3.50**	**3.37**	**35.1**	**52.9**	**.13 loss**	......	**3.08**	**.42 loss**	......	**3.66**	......	**.16 gain**
Three fed flocks													
Pen 8 (3 year olds)........	93.6	3.78	3.57	28.6	71.4	.21	......	3.80	....	.02	3.98	......	.20
Pen 22 (2 year olds)........	100.1	3.22	3.40	47.3	47.3	....	.16	3.38	....	.12	3.80	......	.58
Pen 25 (1 year olds)........	98.6	3.48	3.36	39.3	54.5	.12	......	3.58	....	.10	3.45	.03	....
Average of 3 fed flocks...	**97.4**	**3.49**	**3.44**	**38.4**	**57.7**	**.05 loss**	......	**3.58**	....	**.08**	**3.74**	......	**.25 gain**

TABLE VI.—COMPARISON OF WEIGHTS AND DAYS MOLTING OF FOWLS OF DIFFERENT AGES.

Two flocks 3 year olds	Average days molting	Average weight at beginning of molt	Average weight at close of molt	Per cent which gained in weight	Per cent which lost in weight	Average loss in weight at completion of molt	Average gain in weight at completion of molt	Average weight at close of first four weeks	Average *loss* at end of first four weeks	Average *gain* at end of first four weeks	Average weight Jan. 12, 1907	Average *loss* in weight from Aug. 11, 1906	Average *gain* in weight from Aug. 11, 1906
	da.	lb	lb	%	%	lb	lb	lb	lb	lb	lb	lb	lb
Pen 5 (starved)...............	113.6	3.91	3.49	8.1	81.0	.42	......	3.44	.47	......	3.73	.18	......
Pen 8 (fed)...................	93.6	3.78	3.57	28.6	71.4	.21	......	3.8	......	.02	3.98	......	.2
Average for 3 year olds......	**103.6**	**3.84**	**3.53**	**13.3**	**76.2**	**.31**	......	**3.62**	......	......	**3.85**	......	......
Two flocks 2 year olds													
Pen 19 (starved)...............	102.4	3.15	3.32	63.1	34.1	......	.17	2.86	.29	......	3.68	......	.53
Pen 22 (fed)...................	100.1	3.22	3.40	47.3	47.3	......	.16	3.38	......	.12	3.8	......	.58
Average for 2 year olds......	**101.3**	**3.18**	**3.36**	**55.2**	**40.7**	......	**.16**	**3.12**	......	......	**3.74**	......	**.55**
Two flocks 1 year olds													
Pen 24 (starved)...............	65.5	3.46	3.3	34.0	43.7	.16	......	2.94	.52	......	3.57	......	.11
Pen 25 (fed)...................	98.6	3.48	3.36	39.3	54.5	.12	......	3.58	......	.10	3.45	.03	......
Average for 1 year olds......	**82.0**	**3.47**	**3.33**	**36.6**	**49.1**	**.14**	......	**3.26**	......	......	**3.51**	......	......

ages (Fig. 16, C). From August 11, the beginning of the experiment, there was a gradual decline in production with all the flocks until the latter part of December. From this time production increased rapidly until the latter part of April, when it remained practically stationary until the middle of May; then it declined gradually until the close of the experiment, November 8. These observations agree with similar ones made in other experiments.*

All of the above principles are clearly illstrated in Fig. 16, 17 and 18, A, B and C, where the starved and fed flocks are compared.

Egg-production during the molt.

The fact that hens, though well fed, lost weight in the process of molt would indicate something of the strain imposed on them by the production of new feathers. This is more noticeably shown by the falling off in egg-production (Tables IV, V, VI and VII, Figs. 16, 17 and 18). The trap-nested hens, pen 24 (starved), and pen 25 (fed), averaged only 12 eggs laid while molting. Only three per cent of the hens laid in the heavy molting season and only one of the 65 trap-nested hens produced more than an occasional egg during that time (Figs. 16, 17 and 18).

It is apparent that, as molting increased, egg-production decreased (Fig. 18, A and B, and Tables IV, V and VI). This was true almost without exception with both starved and fed flocks during each period. It was strikingly true during the starvation period. While some of the hens continued to lay after beginning to molt, and a few began to lay before completing their new coat, no hen continued to lay during the entire molting period.

Influence of prolificacy on the time and rapidity of molt.

Persistent layers, unless broody, appeared to begin the molt within a week after the last egg, and were usually in heavy molt in less than two weeks. Those beginning to molt after October first shed more quickly and re-feathered more quickly than those molting earlier, especially to the stage of advanced molt, when their bodies were well protected (Tables IV, V and VI, and Figs. 18, 19 and 20). Hen Number 61 (Figs. 19 and 20) was a good example. It was 56 days from the time she began to shed until she had grown a complete coat of feathers.

Influence of broodiness on the molt.

Broodiness influenced the time of molt to a great degree. In this experiment, a number of hens became broody, and were allowed to sit

* Bulletin 249, Cornell Experiment Station, "Four Methods of Feeding Pullets."

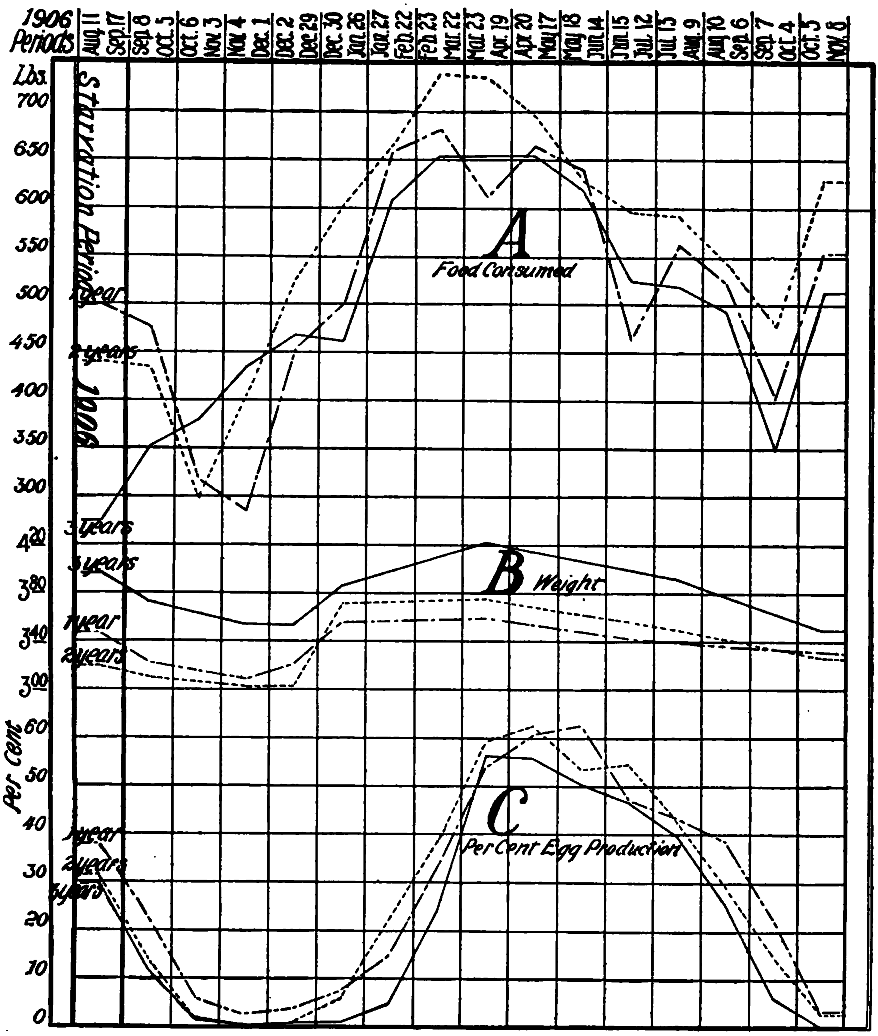

FIG. 16.—*A comparison of one, two and three year olds per period of 28 days, of both starved and fed fowls. A=Consumption of food. B=Weight of fowls. C=Percentage egg production. Note that an increase or decrease in weight is usually preceded by corresponding increase or decrease in the amount of food consumed by each flock, and that an increase or decrease in per cent egg production is preceded by a corresponding increase or decrease in weight of each flock. It will also be observed that there is great uniformity between the various flocks each period as to increase or decrease in food consumption, weight and per cent egg production.*

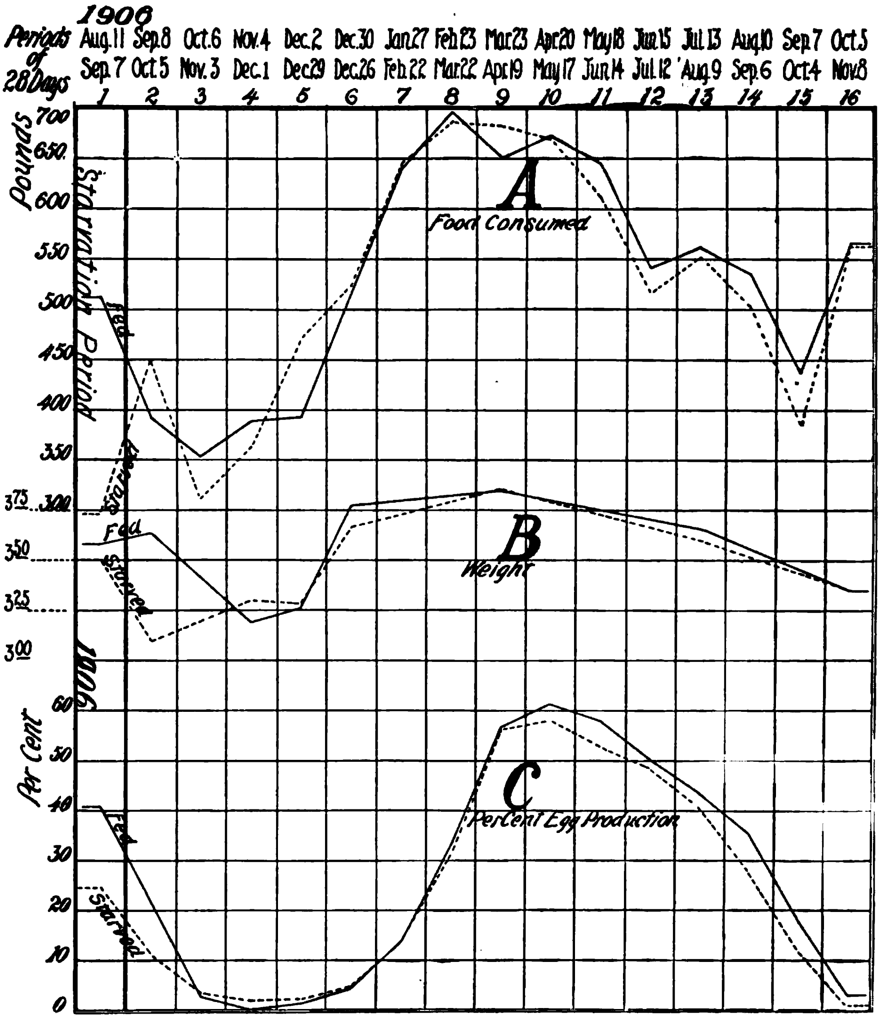

FIG. 17.—*A comparison of starved and fed flocks, by periods of 28 days. A=Consumption of food. B=Weights of fowls in pounds. C=Per cent production of eggs.*

Fed flocks—Pens 8 (3 years old), 19 (2 years old) and 24 (1 year old).

Starved flocks—Pen 5 (3 years old), 22 (2 years old) and 25 (1 year old).

Note that the same general observations as to the increase or decrease in the food consumed, weight and percentage egg-production applies in the same manner as observed in Fig. 16.

for periods varying from three or four days to four weeks. In no instance did a hen shed more than a few feathers while broody. Some hens which had begun to molt and had subsequently become broody, ceased molting until broken of broodiness. When broken up they began to molt quickly, and shed and re-feathered rapidly and completely (Table VIII).

The hens in the starved flocks showed considerably more broodiness than did those in the fed flocks. During the experiment there was, among the starved flocks, an average of 67 individuals broody for each flock, having an average loss per flock of 459 broody days, as compared to an average, among the fed flocks, of 38 broody individuals, having an average loss for each flock of 320 broody days.

It will be seen (Table VIII) that with the fowls of different ages there were all told, 66 three-year-olds broody, 140 two-year-olds and 110 one-year-olds. The days lost were: three-year-olds, 396 days; two-year-olds, 1,140 days; one-year-olds, 802 days. Just why the two-year-old hens should have been more broody than fowls of the other ages is not understood.

Mortality.

The mortality in all the pens was large. It averaged 18.8% among the starved and 20% among the fed flocks. The two flocks of three-year-olds had a mortality of 21%; the two-year-olds, 16%, and the one-year-olds, 20%. The figures are for the entire experiment of one year and 90 days, and included all the hens in all the pens. There was no especial selection as to vigor when the experiment began and no substitution of strong fowls for those which became weak or died during the progress of the experiment.

Influence of method of feeding on egg-production and molt.

Production is the real test of a method of feeding. The starved hens averaged 17.3 eggs from the close of their individual molt to April first, while the fed hens averaged 16.6 eggs during the same period; an average in all the flocks of 16.9 eggs. The yearly production was, however, not in favor of the starved hens. which gave only 102 eggs per year while the fed hens laid 119 eggs each in the same period

It is considered important that hens should quickly resume production after molt. In this experiment, the average days after molt before production began, was, in the trap-nested flocks (65 hens), 39 days after the completion of the individual molt. The starved hens began to lay in 35 days and the fed hens in 44 days, or nine days later.

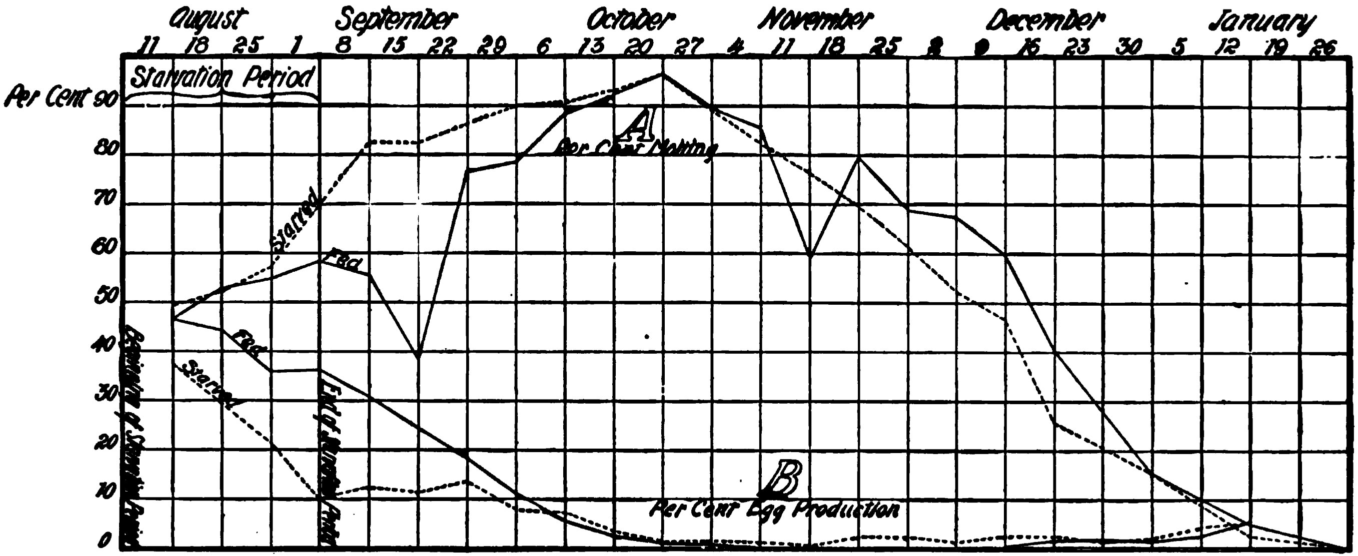

FIG. 18.—*A comparison of molting and egg production during molt. Average of three starved and three fed pens. Periods of 7 days. Starved..........Pens 5, 19, 24. Fed————Pens 8, 22, 25. Note that during the molting season as the per cent molt increased in the flocks the per cent egg production decreased, and that as the per cent molting decreased the per cent egg production increased.*

Relative influence of time of molt one season on time of molt the following season.

The question naturally arises whether hens tend to molt at the same season in successive years. Careful observations of trap-nested hens (one-year-olds) in the molting seasons of 1906 and 1907 showed that, of both flocks (65 hens), 78.5 per cent molted at practically the same season in two successive years. Where the hens had been fed in the same way during the two years, 87.5 per cent molted at about the same time. The hens which had been starved one year to hasten the molt, and fed after the usual method the next year, did not molt as early the second year as the first. In other words, the so-called "forced molt" held good for only one season, and possibly delayed molting somewhat the second year.

It is apparent from the plotted curves of percentages of (A) egg-production and (B) hens molting, that early molting causes early decline in the production and that late molting tends to postpone the time of decline (Fig. 21). This figure also serves to indicate that the older fowls have a tendency to molt later than the younger. Notice also that the fed flocks began to molt considerably later during their second year, 1907, than they did during their first year, 1906. Inasmuch as the same tendency was observed with both starved and fed flocks it would appear that the lateness of molting in the second year might be due more to the age of the fowls than to the methods of feeding.

Forty-five per cent of the starved hens began to lay at about the same time in 1907 as they did in 1906. With the fed hens it was about sixty-three per cent. In 1906 (the year of starving) seventy-nine per cent of the starved hens began laying earlier than in 1907, and the entire *starved* flock averaged 24 days earlier in 1906 (Fig. 21).

Hens that shed late take less time to molt.

In these observations it was found that the hens, from all pens, which began to molt before September 15th, averaged 108 days molting, while those which began after that date molted in 81 days. This condition seems, in the case of the one-year-olds, to be modified by the method of feeding. Of the fed one-year-olds, the hens which molted early averaged 35 days longer in molting than those which molted later; but of the starved one-year-olds, those which shed early averaged two days less in molting than those which shed later. The eight hens, from both of these pens, which began molt after October first averaged 82 days molting. In every case where the molt appeared to be uninfluenced

TABLE VII.

Periods	Per cent Egg Production of Starved and Fed Fowls by Periods of 28 Days. (See also Fig. 16).								Per cent Egg Production of Fowls of Three Different Ages by Periods of 28 Days.								
	Starved				Fed				Three Years			Two Years			One Year		
	5 3 year olds	19 2 year olds	24 1 year olds	Ave.	8 3 year olds	22 2 year olds	25 1 year old	Ave.	5 Starved	8 Fed	Ave.	19 Starved	22 Fed	Ave.	24 Starved	25 Fed	Ave.
1 Aug. 11–Sep. 7..	27.5	24.28	22.81	24.86	31.89	38.25	52.60	40.91	27.5	31.89	29.69	24.28	38.25	31.26	22.81	52.60	37.70
2 Sep. 8–Oct. 5....	10.8	9.64	13.33	11.26	13.00	18.96	32.42	21.46	10.8	13.00	11.90	9.64	18.96	14.30	13.33	32.42	22.87
3 Oct. 6–Nov. 3...	1.5	2.35	6.35	3.40	1.17	1.28	5.71	2.72	1.5	1.17	1.33	2.35	1.28	1.81	6.35	5.71	6.03
4 Nov. 4–Dec. 1...	.46	.....	4.93	1.79	.....	.....	.....	.....	.46	.....	.23	.....	.....	.....	4.93	.....	2.46
5 Dec. 2–Dec. 29..	.46	.71	5.35	2.17	.89	.71	2.03	1.21	.46	.89	.67	.71	.71	.71	5.35	2.03	3.69
6 Dec. 30–Jan. 26..	1.14	4.28	8.82	4.75	.50	7.03	5.85	4.46	1.14	.50	.82	4.28	7.03	5.65	8.82	5.85	7.33
7 Jan. 27–Feb. 22..	3.17	20.96	16.32	13.48	6.50	22.22	13.25	13.66	3.17	6.50	4.83	20.96	22.22	21.59	16.32	13.25	14.78
8 Feb. 23–Mar. 22.	21.6	36.78	34.14	30.84	26.57	40.00	32.03	32.87	21.6	26.57	24.08	36.78	40.00	38.39	34.14	32.03	33.08
9 Mar. 23–Apr. 19.	53.3	60.89	53.90	56.03	59.32	57.14	53.84	56.77	53.3	59.32	56.31	60.89	57.14	59.01	53.90	53.84	53.87
10 Apr. 20–May 17.	51.2	64.60	58.20	58.00	60.28	60.53	63.25	61.35	51.2	60.28	55.74	64.60	60.53	62.56	58.20	63.25	60.72
11 May 18–June 14.	43.8	54.03	60.80	52.88	56.82	52.92	64.39	58.04	43.8	56.82	50.31	54.03	52.92	53.47	60.80	64.39	62.59
12 June 15–July 12.	41.5	58.21	45.90	48.54	52.23	50.46	48.56	50.42	41.5	52.23	46.86	58.21	50.46	54.33	45.90	48.56	47.23
13 July 13–Aug. 9..	35.7	45.46	41.12	40.76	44.23	40.50	45.96	43.56	35.7	44.23	39.96	45.46	40.50	42.98	41.12	45.96	43.54

14	Aug. 10–Sept. 6..	19.3	28.85	35.10	27.75	32.53	30.70	42.85	35.36	19.3	32.53	25.91	28.85	30.70	29.77	35.12	42.85	38.98
15	Sep. 7–Oct. 4....	4.6	12.42	18.75	11.92	7.96	17.96	27.35	17.76	4.6	7.96	6.28	12.42	17.96	15.19	18.75	27.35	23.05
16	Oct. 5–Nov. 8...	.....	.60	2.94	1.18	.31	5.34	4.00	3.22	.....	.31	.15	.60	5.34	2.97	2.94	4.00	3.47
	Average per cent production per year...	19.75	26.50	26.79	24.35	24.63	27.76	30.88	27.73	19.75	24.63	22.19	26.50	27.76	27.12	26.79	30.88	28.83

TABLE VIII.

MORTALITY AND BROODINESS ON A 100 HEN BASIS OF ALL OF THE PENS.

	Starved				Fed			
	5 3 years old	19 2 years old	24 1 year old	Average	8 3 years old	22 2 years old	25 1 year old	Average
Mortality (per 100)...........	25.00	14.29	17.14	18.81	18.42	18.18 *(11.36)	23.52	20.04
Broodiness (days lost).........	220 da.	738 da.	420 da.	459.3 da.	176 da.	402 da.	382 da.	320 da.
Number Individuals Broody......	42.5	97.6	62.8	67.6	23.7	43.19	47.34	38.1

*Actual deaths, 18.18 includes fowls that were stolen.

by the feeding, the late molting hens took less time to produce a new coat of feathers than did those which molted earlier.

Hens that molt early lay more early winter eggs.

The hens molting before September 15, began to lay 39 days after the completion of the individual molt; those molting after September 15 began to lay in 43 days after they were completely refeathered. The hens which molted before September 15 averaged 17 eggs each from the completion of their individual molt to April 2nd, 1907, while those molting later gave 14 eggs each in the same period.

Hens that molt late lay more eggs during the year.

Although the early molting hens laid more winter eggs, they did not lay more eggs during the year. Those beginning to molt before September 15th, averaged 103 eggs, and those molting later averaged 126 eggs. The eight hens which, in 1906, began to molt after October 1st, laid in that year 142 eggs each. Two of the eight hens died in 1907, but the other six gave 129 eggs each in 1907, their third year of laying. The best hen, Number 61, laid 213 eggs in 1906 and 175 eggs in 1907, and was the last one to molt in 1906 and 1907 (Figs. 19 and 20). Thus, the later molting hens consumed less time in molting, and laid more eggs during the year; the early molting hens began to lay more quickly after molt, and gave slightly greater winter production.

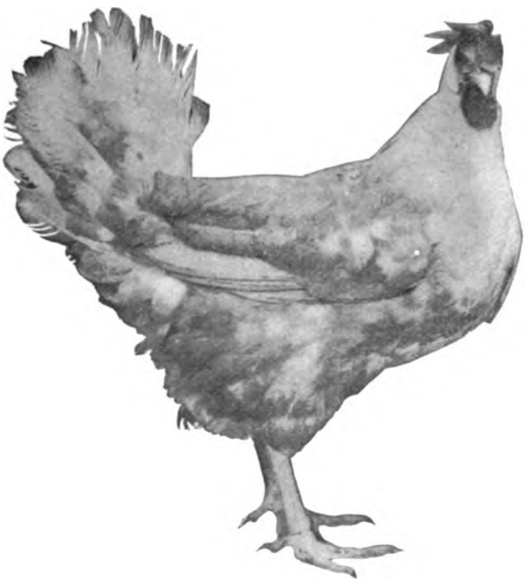

FIG. 19.—*Hen No. 61. In full laying and not molting, October 12, 1906. Record 213 eggs in 261 days, January 24 to October 12, 1906. The best laying hen in the experiment and the last one to molt.*

The early molting hens averaged 3 eggs more in winter when eggs were high than did the late molting hens. For 100 hens this would mean 300 eggs, or 25 dozen. With eggs at 35.5c per dozen (average

for that period in 1907) this would make an additional profit of \$8.87 in favor of early molting, if the additional amount of food consumed on account of the increased production is not considered.

The late molting hens gave 23 more eggs each during the year than the early molting hens. For 100 hens this would be 2300 eggs, or 191.6 dozens. At 29.3c per dozen (average price from August 1906 to August 1907) this would amount to \$56.13 extra profit for the late molting hens, if extra amount of food consumed is not considered. The comparative profit of the late molting hens over the early molting hens, without considering extra food consumed, would be \$56.13 as against \$8.87 = \$47.26. If one should judge from this record, he might conclude that the best laying hens are often latest to molt; therefore, if condition of feeding, age of stock and environment are similar, the one who kills the late molting hens may be killing the best producers.

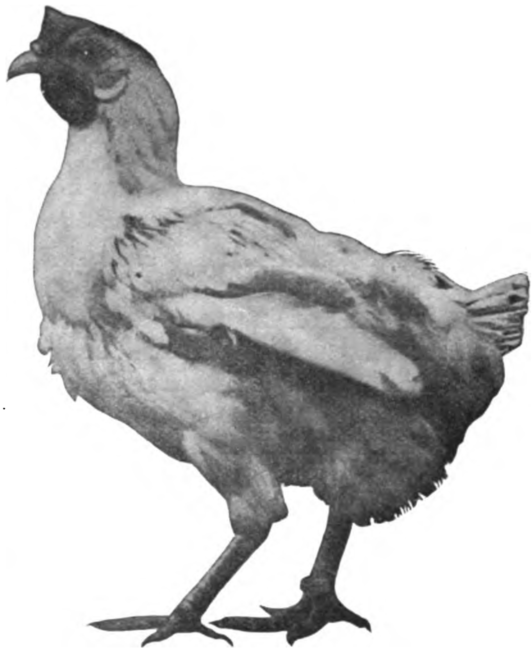

FIG. 20.—*Hen No. 61 in Heavy Molt, November 28, 1906. Observe the old primary and secondary wing feathers still unshed, while the new body and tail feathers are partially developed and the neck feathers well grown. Would you have killed her because she molted late if you had not known her egg record?*

Feather-making demands nitrogenous food.

It is generally conceded that the molting period is the most trying time of a fowl's life. In nature, the shedding of the feathers and the growing of a new plumage apparently occurs in a period of rest following one of production. This period of molting normally comes with regularity at a certain season of the year and presumably is primarily a matter of inheritance, and only secondarily due to environment. Environment may, however, modify, *i. e.* hasten or retard, the natural process. Whatever the condition influencing the molt may be, it appears

that the demands of the body for nourishment from which to grow new plumage is great. This is made apparent by the chemical composition of the feathers, and also by the fact that only the strongest hens appear to be able to produce feathers and eggs at the same time, even for a short period. Table IX shows clearly by comparison the relative amounts of nitrogen and mineral matter contained in the body, the eggs and the feathers of the average 100 Leghorn fowls.

It may be reasoned that it takes nearly a year to grow the body of a hen, that young growing stock eat more per pound weight than mature hens not in production, and that a year's production of eggs is estimated to contain twice as much nitrogen as a hen's body. We also know that

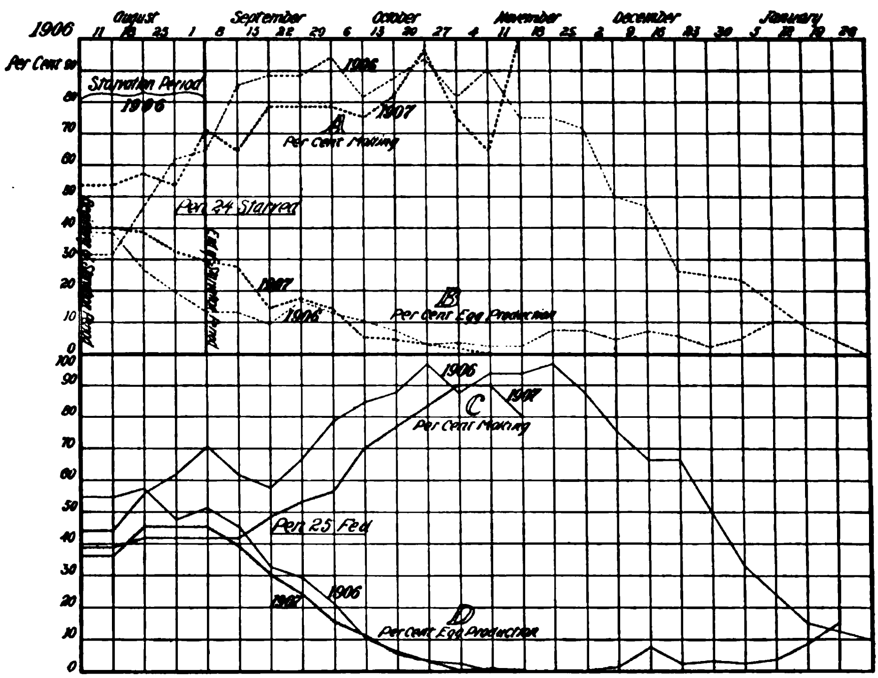

FIG. 21.—*A comparison of per cent Molting and per cent Egg Production in two successive years between flocks 24 (starved) and flock 25 (fed). Trapnested hens. Pens 24 starved and 25 fed, Periods of 7 days.*

........=Starved flock.

————=Fed flock

Note again the regularity with which the per cent egg production increases or decreases as the per cent molting increases or decreases. Also observe that the molting was later the second year than it was the first year, and that the starving process did not materially influence the time of molt the following year.

a hen will eat much more food while in heavy laying than when not in production. In contrast to this, the new coat of feathers, produced in about one-fourth of a year, contains one-fifth as much nitrogen as her body, and one-tenth as much nitrogen as her yearly egg product. Since the increase in body, and the production of eggs, demand an increased supply of food, we may safely conclude that the renewal of plumage will require a liberal, easily digestible food supply, presumably rich in nitrogen; especially so when the molt comes at the end of an exhausting period of production.

It is worthy of note in this connection to compare the amount of lime found in the flesh, the eggs, and the feathers of the average 100 Leghorn fowls. (Table IX.) While the feathers do not appear to contain any considerable amount of lime, the eggs, on the other hand, contain about ten times as much mineral matter as the body of the fowl. There appears to be about 13½ pounds of mineral matter in the bodies of 100 Leghorn hens and 125 pounds in the eggs which they normally produce.

TABLE IX.—ESTIMATED NITROGEN AND MINERAL MATTER IN THE BODY, FEATHERS AND EGGS PER 100 FOWLS.

Pen	Age	Method of Feeding	Nitrogen lbs			Ash lbs Mineral Matter		
			Body	Eggs	Feathers	Body	Eggs	Feathers Lime only
5	3 yr.	Starved	12.86	18.02	2.38	14.17	99.36	.023
8	"	Fed	13.28	21.87	2.45	14.63	120.58	.024
19	2 yr.	Starved	11.31	23.54	2.09	12.40	129.76	.020
22	"	Fed	11.66	24.03	2.15	12.84	132.44	.021
24	1 yr.	Starved	11.55	22.93	2.13	12.73	126.40	.020
25	"	Fed	11.69	25.87	2.16	12.98	142.59	.021

This table was computed on the first 13 periods of the experiment, covering a period of 364 days. It was assumed that the hen shed and replaced her entire plumage once in this time. The quantity of feathers per hen was estimated at 4.53% of the total weight of the fowl.* Only

* Theses on "Comparative Anatomy of Various Breeds of Fowls to Show Type Differences," by C. A. Rogers and H. C. Pierce, Cornell University, 1905 and 1906.

the lime content in the feathers was used in computing the mineral content of feathers. The analyses used were as follows:

Body...Nitrogen 3.45%; Ash 3.8%; "Jordan."
Feathers " 14.10%; Lime .138%; "Bizzell."
Egg..... " 1.76%; Ash 9.7%.

Fertility and hatching-power of the eggs.

The following tabulation shows that for the entire hatching season, the average fertility of the eggs and hatching-power of the fertile eggs was not high, and that the difference which existed could hardly be attributed to the method of feeding the fowls in the molting season.

PERCENTAGE OF FERTILITY AND HATCHING-POWER OF EGGS.

Pens	Starved				Fed			
	5	19	24	Total	8	22	25	Total
No. eggs inc.	115	89	989	1193	164	Male poor—no fertility	969	1133
Per cent fertile	67.82	82.02	68.35	69.32	90.24		63.56	67.43
Per cent of Fertile eggs hatched	46.14	56.14	68.04	64.93	63.29		70.45	69.89

The hatching season of the three-year-old hens (pens 5 and 8) was March and April; the two-year-old hens (pens 19 and 22) was December, January and April; the one-year-old hens (pens 24 and 25) was February to August, inclusive. A fair comparison between the flocks of the different ages as to fertility and hatching-power of the eggs therefore, cannot be made, because the early winter and late summer months are, as a rule, less favorable for the fertility and hatching-ability. Such was the case in this experiment.

A comparison, however, can accurately be made between the starved and fed flocks since they each contained fowls of the three ages. It will be seen that the fertility of the eggs, from the starved flocks, averaged 69.3%, and from the fed flocks, 67.4%; while the hatching-power of the fertile eggs was, for the starved flocks, 64.9%, and the fed flocks, 69.8%, a difference of about 5% in favor of the fed flocks. The large number of eggs incubated (1193 from the starved flocks and 1133 from the fed flocks) gives a fair basis for this estimate. The conditions of incubation of the eggs from the starved and the fed flocks, while not identical, were, nevertheless, so similar as to render a comparison as to hatching-power justifiable.

The method of feeding fowls in the molting season affects the profits.

The final test of any system of handling fowls in the molting season will be the effect on the cost of production, in this instance, primarily, egg-production. Table X gives the cost of a dozen eggs with each flock for each of the sixteen periods of 28 days and the average cost per dozen for each flock throughout the entire experiment. The cost per dozen, however, does not necessarily indicate the actual profits per hen. For example, the starved flocks, because they were eating less feed during the first period, produced eggs at about the same cost ($.076 per dozen) as the fed flocks ($.074 per dozen). The former laid 66.1 dozens of eggs at a net profit of $8.57, while the latter laid 106.8 dozens of eggs at a net profit of $17.02. (Tables X, XI, XII and XIII, and Fig. 22.)

It will be observed from an examination of Table X that the price per dozen eggs per period varies between wide limits. This is due to the fact that the cost of the maintenance ration forms a large part of the expense of keeping a hen. This must be charged up against the hen whether she lays or not. The more eggs that are laid, the less will be the share of the maintenance to be charged up against the cost of each dozen of eggs produced. In other words, the cheapest eggs are produced, as a rule, during the periods of highest average production. In order to verify this statement, compare the cost per dozen eggs with the normally fed flocks for the periods of highest average production; namely, March 23 to April 19=$.066 per dozen; April 20 to May 17= $.065 per dozen; May 18 to June 14=$.068 per dozen. On the other hand, with the periods of lowest average production;—November 4 to December 1, when no eggs were produced, the cost of care and feed was an entire loss. December 2 to December 29, the eggs cost $2.73 per dozen; December 30 to January 26, $1.99 per dozen. The contrast with the starved flocks was even greater than it was with the ones under normal conditions.

A study of Fig. 22 B will show the season of the year when the profits are likely to be affected by the starvation process of "forcing the molt." In the first three periods of the experiment (that is, the 28 days of starvation and the two periods of 28 days each that followed) the hens declined so rapidly in egg production that they failed to pay a profit over the cost of feed. The fed pens, during this time, while declining in their production through the natural conditions of molt at this season, nevertheless continued to pay a profit until the fourth and fifth periods, November and December. The prices of eggs during the months of August, September and October always rule high and the eggs laid at this season, during the normal conditions of molt, are of considerable

TABLE X.—COST PER DOZEN EGGS PER PEN PER PERIOD OF TWENTY-EIGHT DAYS.*

Periods of 28 days	Three Year Olds			Two Year Olds			One Year Olds			Starved				Fed			
	5 Starved	8 Fed	Ave.	19 Starved	22 Fed	Ave.	24 Starved	25 Fed	Ave.	5 3 year olds	19 2 year olds	24 1 year olds	Ave.	8 3 year olds	22 2 year olds	25 1 year olds	Ave.
1 Aug. 11–Sep. 7..	.039	.072	.055	.072	.085	.018	.116	.065	.090	.039	.072	.116	.076	.072	.085	.065	.074
2 Sep. 8–Oct. 5...	.198	.155	.176	.288	.112	.200	.227	.079	.153	.198	.288	.227	.337	.155	.112	.079	.115
3 Oct. 6–Nov. 3...	1.423	2.000	1.711	5.814	1.503	3.658	.277	.308	.292	1.423	5.814	.277	2.504	2.000	1.503	.308	1.270
4 Nov. 4–Dec. 1..	5.920	.....	†5.920	.....	.....	.....	.295	.....	†.295	5.920	.....	.295	†3.107	.....	.....	.....	.....
5 Dec. 2–Dec. 29..	5.324	2.880	4.102	4.09	4.091	4.09	.488	1.242	.865	5.324	4.09	.488	3.301	2.880	4.091	1.242	2.734
6 Dec. 30–Jan. 26.	2.142	5.08	3.611	.82	.463	.641	.307	.421	.364	2.142	.82	.307	1.089	5.08	.463	.421	1.988
7 Jan. 27–Feb. 22.	1.000	.49	.745	.172	.161	.166	.214	.203	.208	1.000	.172	.214	.462	.49	.161	.203	.284
8 Feb. 23–Mar. 22	.148	.13	.139	.110	.092	.102	.105	.109	.107	.148	.110	.105	.121	.13	.092	.109	.110
9 Mar. 23–Apr. 19	.071	.063	.067	.095	.073	.084	.071	.062	.066	.071	.095	.071	.079	.063	.073	.062	.066
10 Apr. 20 May–17.	.079	.066	.072	.071	.067	.069	.072	.063	.067	.079	.071	.072	.074	.066	.067	.063	.065
11 May 18–June 14	.085	.066	.075	.066	.072	.069	.060	.065	.062	.085	.066	.060	.070	.066	.072	.065	.068
12 June 15–July 12	.071	.062	.066	.063	.066	.064	.054	.068	.062	.071	.063	.054	.063	.062	.066	.068	.065
13 July 13–Aug. 9.	.079	.067	.073	.075	.085	.080	.073	.071	.072	.079	.075	.073	.076	.067	.085	.071	.074
14 Aug. 10–Sep. 6...	.137	.088	.112	.107	.108	.107	.083	.072	.077	.137	.107	.083	.109	.088	.108	.072	.089
15 Sep. 7–Oct. 4...	.481	.281	.381	.227	.162	.194	.112	.089	.100	.481	.227	.112	.273	.281	.162	.089	.177
16 Oct. 5–Nov. 8...	.....	7.802	7.802	4.80	.547	.513	.870	.620	.745	.....	4.800	.870	2.835	7.802	.547	.620	2.989
Ave. cost per dozen eggs for the entire year and 90 days.	$.147	$.119	$.133	$.124	$.124	$.124	$.108	$.097	$.102	$.147	$.124	$.108	$.126	$.119	$.124	$.097	$.113

* Average cost per dozen eggs for periods of 28 days each, including the season of least production twice.
† Computed without considering the vacant columns.

TABLE XI.—FINANCIAL STATEMENT OF THE NET PROFIT PER 100 HENS BY 28 DAY PERIODS.
A COMPARISON OF METHODS OF FEEDING.

	Periods of 28 days +=Profit. —=Loss.	STARVED				FED			
		5 3 years old	19 2 years old	24 1 year old	Average	8 3 years old	22 2 years old	25 1 year old	Average
1	Aug. 11–Sep. 7	$12.33 +	$7.27 +	$6.12 +	$8.57 +	$13.58 +	$14.19 +	$23.30 +	$17.02 +
2	Sep. 8–Oct. 5	4.95—	7.18—	6.50—	6.21—	2.25 +	4.88 +	14.99 +	7.37 +
3	Oct. 6–Nov. 3	4.92—	1.18—	.28—	2.12—	6.54—	3.41—	.80 +	3.05—
4	Nov. 4–Dec. 1	4.34—	1.19 +	1.48 +	.56—	10.96—	13.98—	12.80—	12.58—
5	Dec. 2–Dec. 29	8.05—	7.26—	1.47 +	4.61—	4.65—	7.26—	2.13—	4.68—
6	Dec. 30–Jan. 26	.35 +	5.23 +	5.49 +	3.69 +	1.33 +	9.75 +	1.45 +	4.17 +
7	Jan. 27–Feb. 22	8.41—	4.16 +	2.10 +	.71—	2.70—	7.72 +	.60—	1.47 +
8	Feb. 23–Mar. 22	4.15 +	14.10 +	13.50 +	10.58 +	5.72 +	15.56 +	9.49 +	10.25 +
9	Mar. 23–Apr. 19	25.53 +	17.68 +	16.61 +	19.94 +	23.17 +	17.31 +	16.18 +	18.88 +
10	Apr. 20–May 17	14.63 +	17.75 +	17.60 +	16.66 +	19.18 +	15.82 +	12.15 +	15.71 +
11	May 18–June 14	13.81 +	17.39 +	22.72 +	17.97 +	20.50 +	18.27 +	20.81 +	19.86 +
12	June 15–July 12	11.83 +	21.21 +	17.77 +	16.93 +	15.99 +	16.19 +	16.50 +	16.22 +
13	July 13–Aug. 9	4.93 +	11.25 +	13.71 +	9.96 +	7.09 +	8.47 +	14.52 +	10.02 +
14	Aug. 10–Sep. 6	1.70 +	11.18 +	15.93 +	9.60 +	14.36 +	12.18 +	20.55 +	15.69 +
15	Sep. 7–Oct. 4	1.79—	2.53 +	6.90 +	2.54 +	.65 +	6.40 +	14.40 +	7.15 +
16	Oct. 5–Nov. 8	19.70—	11.80—	4.17—	11.86—	14.59—	6.99—	9.61—	10.39—
	Totals	$37.10 +	$104.02 +	$130.45 +	$90.52	$84.38 +	$114.10 +	$140.00 +	$112.82

TABLE XII.—FINANCIAL STATEMENT OF THE NET PROFIT PER 100 HENS BY 28 DAY PERIODS. A COMPARISON OF AGES.

Periods of 28 days. +=Profit. —=Loss.	Three years			Two years			One year		
	5 Starved	8 Fed	Average	19 Starved	22 Fed	Average	24 Starved	25 Fed	Average
1 Aug. 11–Sep. 7...	$12.33+	$13.58+	$12.95+	$7.27+	$14.19+	$10.73+	$6.12+	$23.30+	$14.71+
2 Sep. 8–Oct. 5.....	4.95—	2.25+	1.35—	7.18—	4.88+	1.15—	6.50—	14.99+	4.25+
3 Oct. 6–Nov. 3....	4.92—	6.54—	5.73—	1.18—	3.41—	2.29—	.28—	.80+	.26+
4 Nov. 4–Dec. 1....	4.34—	10.96—	7.65—	1.19+	13.98—	6.39—	1.48+	12.80—	5.66—
5 Dec. 2–Dec. 29....	8.05—	4.65—	6.35—	7.26—	7.26—	7.26—	1.47+	2.13—	.33—
6 Dec. 30–Jan. 26..	.35+	1.33+	.84+	5.23+	9.75+	7.49+	5.49+	1.45+	3.47+
7 Jan. 27–Feb. 22..	8.41—	2.70—	5.55—	4.16+	7.72+	5.94+	2.10+	.60—	.75+
8 Feb. 23–Mar. 22..	4.15+	5.72+	4.93+	14.10+	15.56+	14.83+	13.50+	9.49+	11.49+
9 Mar. 23–Apr. 19..	25.53+	23.17+	24.35+	17.68+	17.31+	17.49+	16.61+	16.18+	16.39+
10 Apr. 20–May 17..	14.63+	19.18+	16.90+	17.75+	15.82+	16.79+	17.60+	12.15+	14.87+
11 May 18–June 14..	13.81+	20.50+	17.15+	17.89+	18.27+	18.09+	22.72+	20.81+	21.76+
12 June 15–July 12..	11.83+	15.99+	13.91+	21.21+	16.19+	18.70+	17.77+	16.50+	17.13+
13 July 13–Aug. 9...	4.93+	7.09+	6.01+	11.25+	8.47+	9.86+	13.71+	14.52+	14.11+
14 Aug. 10–Sep. 6...	1.70+	14.36+	8.03+	11.18+	12.18+	11.68+	15.93+	20.55+	18.24+
15 Sep. 7–Oct. 4.....	1.79—	.65+	.57—	2.53+	5.40+	4.46+	6.90+	14.40+	10.65+
16 Oct. 5–Nov. 8....	19.70—	14.59—	17.14—	11.80—	6.99—	9.39—	4.17—	9.61—	6.89—
Totals...........	$37.10+	$84.38+	$60.73+	$104.02+	$114.10+	$109.06+	$30.45+	$140.00+	$135.22+

TABLE XIII.—SUMMARY.

FINANCIAL STATEMENT ON A 100 HEN BASIS OF ALL THE PENS FOR THE ENTIRE EXPERIMENT.

	Starved				Fed			
Income	5 3 years old	19 2 years old	24 1 year old	Average	8 3 years old	22 2 years old	25 1 year old	Average
Value eggs	$172.12	$234.54	$249.52	$218.72	$214.96	$254.00	$277.10	$248.69
Value gain in weight	....	1.90	....	.633	....	.57	....	.19
Value outgo	....	....	....	....	....	....	....	....
Cost of food	108.8	123.3	110.40	114.16	109.10	121.20	115.70	115.33
Cost loss in stock	16.83	9.00	8.79	11.54	11.65	10.33	13.76	11.91
Cost loss in weight	5.92	....	.03	1.98	7.59	(6.38)	6.37	4.65
Total income	172.12	236.44	249.52	219.36	214.96	254.57	277.10	248.88
Total outgo	131.55	132.30	119.22	127.68	128.34	131.53	135.83	131.90
Balance profit	**$40.57**	**$104.14**	**$130.30**	**$91.67**	**$86.62**	**$123.04**	**$141.27**	**$116.98**

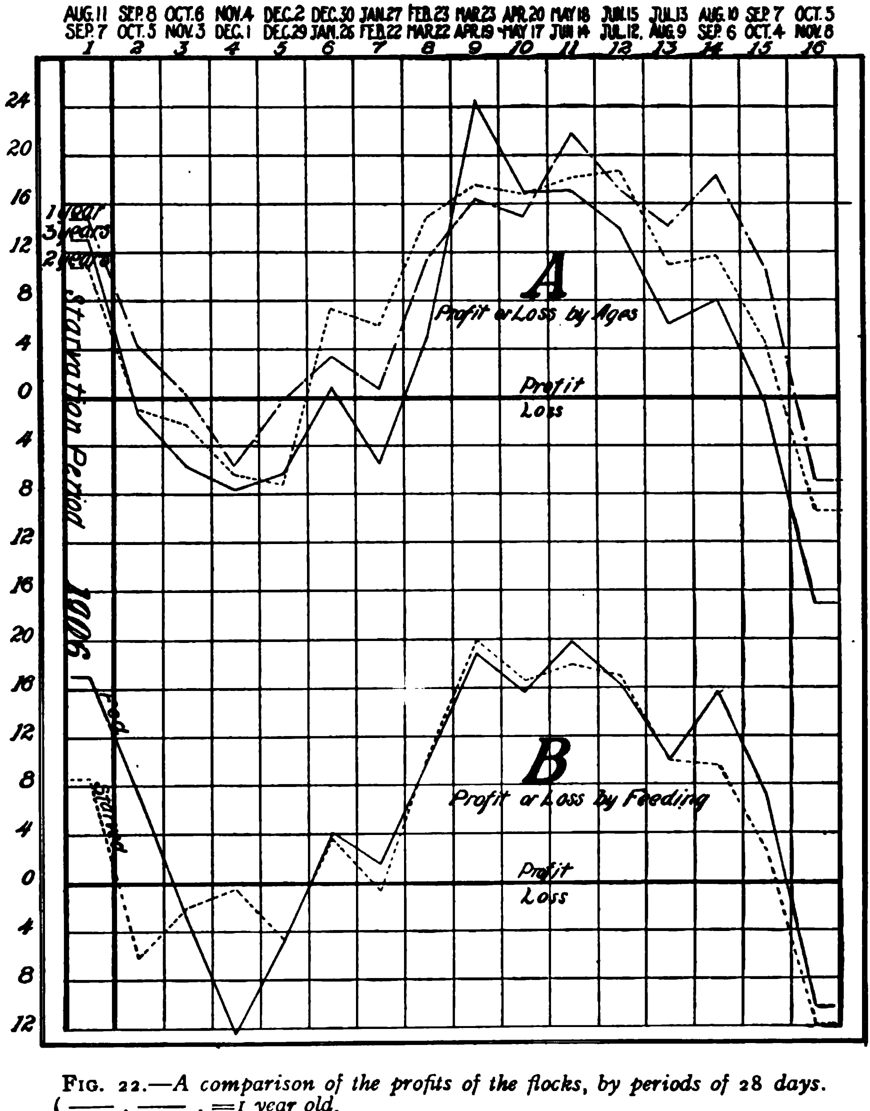

FIG. 22.—*A comparison of the profits of the flocks, by periods of 28 days.*

A { —— . —— . =*1 year old.*
A { . . . . =*2 years old.*
A { ——————*3 years old.*

B { . . . . =*Starved flocks.*
B { ——————*Fed flocks.*

Note that all the flocks were kept at a loss during the months of Oct., Nov. and Dec. and that the starved flocks made a less profit during the starvation period than the fed flocks, and only a slightly less loss during the early winter months and considerably less profit during the latter part of the year.

importance, and may determine the profit or loss per hen for the year. This was the case with thc fed flocks. They continued to pay a fair profit during the molt, while the starved flocks were being kept at a loss. Though the starved flocks laid a few more eggs during early winter than did the fed flocks, they did not lay enough more eggs to overcome the loss during the molting season. This loss was largely due to the starvation process. In the second year the comparative profits ruled higher with the fed hens than they did with the ones which were starved the previous year; both flocks being fed normally the second year. This result would appear to indicate that the starved fowls might have been weakened by their long fast. If so, it was shown only in their egg-production.

From the summary, Table XIII, it will be seen that (estimated on a hundred hen basis) the fed hens laid, during the year, eggs which were worth, at market prices, on the average for each flock, $29.97 more than the eggs laid by the starved hens. They did this at an average cost of $1.17 more for the fed flocks, making the total gross income (when taking into consideration the gain or loss in weight, the loss of stock, the sale of eggs, and the cost of feed, but not including the labor) $219.36 for the starved flocks and $248.88 for the fed flocks, an average gross income, in favor of the fed flocks, of $29.52 per pen, which would be, for the three fed pens, $88.56. The total net income was, for the starved fowls, $278.01, and for the fed flocks, $350.94, leaving a net balance profit, in favor of the fed flocks, of $75.93.

III. GENERAL ADVICE AND SUMMARY.

Method of feeding.

It is generally held that the method of feeding and the quality and quantity of food has much influence on the time, rapidity, and uniformity of molt.

In the absence of reliable data as to the best method of feeding fowls during the critical period of the molt, it would seem desirable to follow the practice commonly believed to be correct: namely, to feed liberally on rations which are easy of digestion and rich in protein and oil. Therefore, in addition to the regular rations, such foods as meat, oil meal, sunflower seed, etc., should be added, or, if already being fed, should be increased in amount. This modified ration is given in order to meet the increased demands of the body for feather-making material at a time when the system presumably would be in need of protein to furnish nitrogen for the growth of feathers and oil to supply available heat for the scantily protected body

What is the normal molt?

From the facts now at hand regarding the molting of fowls, it seems that the best molt, considering the question of the vitality of the stock, is one when the fowl sheds the old feathers and replaces them in a regular sequence with the new, without leaving the individual at any time in an exposed and defenceless condition, and therefore in danger either from inclement weather or inability to escape from its natural enemies.

When fowls molt naturally and well, one should scarcely be able to notice that the flock is molting, except that the shed feathers are found in large quantities about the place. These hens, however, may not be the most highly developed producers. Just how far man may safely go in his development of the productive powers of the hen, without endangering her life or the vitality of her offspring by artificial conditions, remains to be proved. It would appear that one of the first natural results, as a consequence of an increased egg yield, is a postponement of the time of the molt.

Hen number 61 (Figs. 19 and 20) is a good example of the abnormal molt. Her inherited disposition to lay was apparently so strongly developed that it overbalanced the natural habit to molt during the usual and proper season. As a result, she would have paid the penalty of too high production, and retarded molt, by suffering from the November cold, if special care had not been provided for her.

Summary of findings.

(1) The rotation of molting was practically the same with hens of all ages—the oldest feather being shed first.

(2) The chick and hen both feathered more quickly in such areas as would protect the vital parts.

(3) From the incubator to the laying period the chicks experienced at least four molts, either partial or complete.

(4) Hens frequently laid during the summer while partially molting, but seldom during the general molt.

(5) Hens have individual traits as to season of molting, but seldom as to rotation of molt.

(6) Young hens molted more quickly than older ones.

(7) Young hens were more easily influenced by methods of feeding than older ones.

(8) Hens molting very late molted in less time than those molting earlier.

(9) Hens molting very late gave a higher yearly production than those molting earlier.

(10) Hens normally fed tended to molt at the same season in successive years.

(11) The "forced molt" in one year did not influence materially, as to time and completeness, the molt of the succeeding year.

(12) Hens lost in weight while molting.

(13) Hens often regained weight before close of molt, and more especially before commencing to lay.

(14) Broodiness appeared to retard molt.

(15) The starvation process appeared to increase broodiness.

(16) Hens molting early resumed production more quickly after molt than those molting later.

(17) Hens molting early laid more eggs during early winter than hens molting late.

(18) The most prolific hens molted latest.

(19) As compared to the fed flocks, the starved hens

(a) molted slightly earlier and more uniformly. They
(b) were in somewhat better condition at the end of the molt;
(c) molted (average) in slightly less time;
(d) gained less above first weight during molt;
(e) gained slightly more in weight during the year;
(f) resumed production somewhat more quickly after molt;
(g) laid a few more eggs during winter;
(h) were materially retarded in egg production;
(i) produced less eggs after the molt was completed;
(j) produced eggs at a greater cost per dozen;
(k) consumed slightly less food during the year;
(l) had slightly less mortality;
(m) showed slightly more broodiness;
(n) paid a much smaller profit.

(20) The fowls produced the largest profits in the order of their ages. The one-year-old hens produced the greatest number of eggs and gave the largest net profits. The two-year-olds were a close second with the three-year-olds somewhat farther behind, having, however, a good balance profit to their credit.

(21) There was considerably less mortality in the two-year-olds, which were hopper fed dry mash, than in either the one-year-olds or three-year-olds, which were fed a wet mash.

(22) The cost per dozen eggs was greatest in the three-year-old pens, followed closely by the two-year-olds, and was least with the one-year-olds.

(23) Broodiness was greatest in the two-year-olds and least in the three-year-olds.

(24) It was noticeable that broodiness was nearly always confined to a few individuals, and that, although immediately broken up, they became broody again and again.

(25) The fact that there was 67.6 per cent of broodiness in starved pens against 38.1 per cent in the fed pens would indicate that there might be some connection between the amount of food consumed and broodiness in fowls. In this case a restriction in diet appeared to induce broodiness.

(26) It was noticeable with all flocks that they consumed much larger quantities of food and increased in weight before beginning egg-production. This would seem to indicate that the maximum production is preceded by a preparatory stage, during which the body stores up surplus nutrients against a time of need.

The above findings are based on this experiment only and must not be understood to be necessarily conclusive.

General conclusions.

The findings would indicate that with the methods employed, with White Leghorn fowls, one, two or three years old, it does not pay to "force a molt," by starvation method and that apparently it is good policy to encourage hens, by good care and feeding, to lay during late summer and fall, rather than to resort to unusual means to stop laying in order to induce an early molt, with the hope of increasing productiveness during early winter, a season which is naturally unfavorable for egg-production. In short, it appears wise, when hens want to lay, to let them lay.

This experiment should be repeated under similar conditions with the same variety or with different varieties of fowls before final conclusions can be drawn. Molting experiments should also be conducted with various methods of feeding to control the molt before the method of so-called "forcing molt" can be safely accepted or rejected.

CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE

L. H. BAILEY, Director

Department of Plant Biology

TESTING THE GERMINATION OF SEED CORN.*

It is highly important every year that the ears of corn which are to be used for seed be tested as to their ability to germinate. This year, the necessity for this precaution is even greater than usual because last season was so exceptionally short that the vitality of much of the seed corn has been greatly lowered by the freezing weather which occurred while the corn was either still in the field or not sufficiently cured to withstand the low temperature. Poor seed is largely responsible for "poor stands" and "poor stands" mean poor crops.

As an illustration of the importance of such germination tests, the results of an experiment conducted by Professor Holden may be cited. In the spring of 1905, the Agricultural Department of the Iowa State College secured 90 samples from corn that was actually being planted, that is the samples were taken from either the corn planter or the bags of corn seed in the field. These samples were planted by hand, 3 kernels per hill, and treated alike in every respect. The experiment was repeated three times to be sure that no error was made. The following table gives the yield per acre of the six highest yielding samples and also of the six lowest yielding samples:

SIX HIGHEST YIELDING SAMPLES	BU. PER ACRE
Sample No. 59	80.5
" No. 58	80
" No. 66	78.5
" No. 71	77
" No. 138	75
" No. 68	75
Average	77.5

* Prepared by M. P. Jones, under the direction of Dr. H. J. Webber.

SIX LOWEST YIELDING SAMPLES	BU. PER ACRE
Sample No. 44	31.5
" No. 132	33.5
" No. 36	34.5
" No. 32	36.6
" No. 29	37.5
" No. 33	40
Average	35.6

The difference in the average yield of the six highest and six lowest yielding samples is 41.9 bushels per acre, while between sample No. 44 and sample 59, there is a difference of 49 bushels per acre. "This great difference," says Professor Holden, "was due largely to the difference in the vitality of the seed, as in every case the low yielding samples had given a poor stand." These same differences are occurring right here in New York State and for the same reason—poor seed. By testing the germination of corn for planting, seed of strong vitality can be secured and there is probably no one thing which will do more to make the corn crop of New York State average more bushels per acre than the use of seed that will grow.

Since it takes but 15 to 24 ears to plant an acre, it is readily seen that if some of these ears are of low vitality serious loss will result. Some farmers believe that they can tell by simple examination which ears will grow, but even where this ability has been acquired, as the result of long practice, the results are very inaccurate. The only reliable method of determining which ears will grow and which will not is by an actual germination test. A test of this sort is so simple and so easily made that by two hours of actual work enough corn can be tested to plant ten acres. It is safe to say that no time spent in caring for the corn crop will be so well paid for by a corresponding increase in the yield. It is not a question of cost or time, for certainly every grower can afford the little time and expense necessary to make such a test of the seed they expect to plant.

SELECTION OF GOOD SEED EARS.

The first process in the preparation of the seed corn is the selection of the best ears. As every corn grower knows, this selection of the best ears for seed is very important A good ear of corn in general should be cylindrical in shape and of about the same diameter from base to tip. It is very easy to find ears too long and slender to give the best results. The ear giving the largest weight of shelled corn of good quality

FIG. 1.—*Seed ears placed in order of number with germination box in rear.*

and grade is in general the best ear. The ears which give this, ordinarily have deep kernels set on a medium sized cob and are generally well filled at the tip and butt. Length of kernel is one of the most important characters as almost always, if not invariably, high yielding varieties have long kernels. The best form of kernel is wedge shaped, with straight sides and edges. This allows them to occupy all the space on the cob and form a solid heavy ear. They should not be chaffy nor have prolonged chaffy caps.

Select of good ears, a considerable number more than will be necessary to plant a crop of the size desired and then test the germination of each of these ears by the following method.

METHOD OF TESTING GERMINATION.

The simplest way to test sufficient ears for the corn crop on the average sized farm is by means of the germinating box, described by Professor Holden (Figs. 1 and 2). Almost any sort of a box of a depth of from four to eight inches and of a size depending on the number of ears to be tested can be used. Soap boxes or tomato can boxes, which can be obtained at any grocery store, are perfectly satisfactory. Do not use any box so large that it cannot be carried around easily by one man. The box should be half filled with sand or sawdust, preferably sawdust thoroughly moistened, but not saturated. This layer of sawdust should be two or three inches deep, and should be packed down so that the surface will be even and smooth.

A piece of white cloth slightly larger than the size of the box should be ruled off with a lead pencil, checkerboard fashion into squares 1½ to 2½ inches in size. Each square should be numbered consecutively from one upward (Fig. 2). This cloth should be now placed over and in close contact with the sawdust or sand, and tacked to the corners and sides of the box.

The next step is to lay out the seed ears, the germination of which is to be tested. They should be arranged in a row on the floor, a table, or a shelf, in a place where they will not be disturbed (Fig. 1). To avoid mistakes it is well to number every ear. This can be done by writing the number on a little piece of thin cardboard and inserting it between the rows of kernels (Fig. 1) or the number may be written on a piece of paper and this paper fastened by pushing a pin through it into the butt of the cob or held by a rubber band put around the ear. If there is no possibility of the position of the ears being disturbed this precaution may not be necessary.

Now with a pocket knife remove six kernels from each ear. Take one kernel each, from near the tip, middle and butt on one side of the

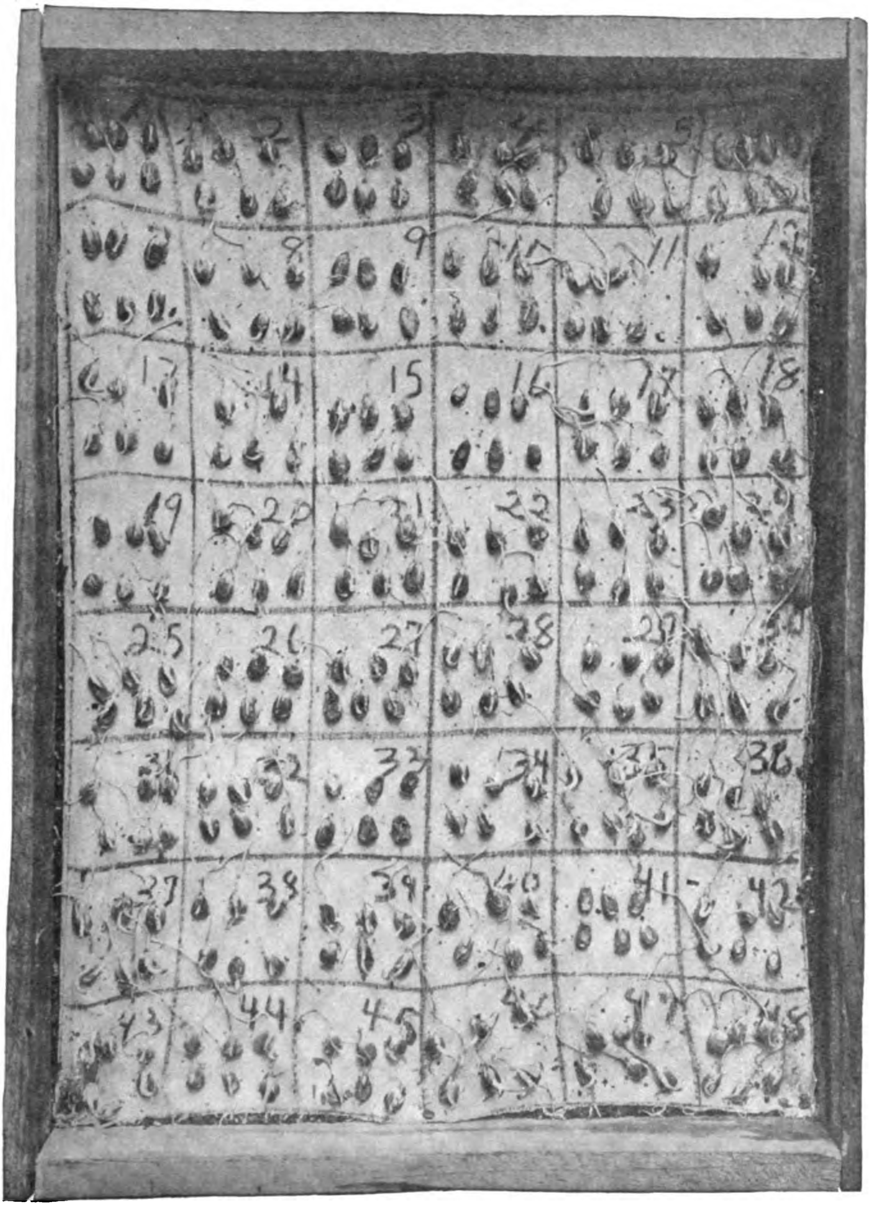

FIG. 2.—*Germination box with kernels in place.*

ear, then turn the ear over and take three more kernels in a like manner from the opposite side of the ear. These should be carefully laid in the square in the box corresponding to the number of the ear. Thus six kernels from ear No. 1 will go in square No. 1 and six kernels from ear No. 2 into square No. 2, and so on. It is best to place the kernels pointing one way and with the germ side up. (Figs. 2 and 3.)

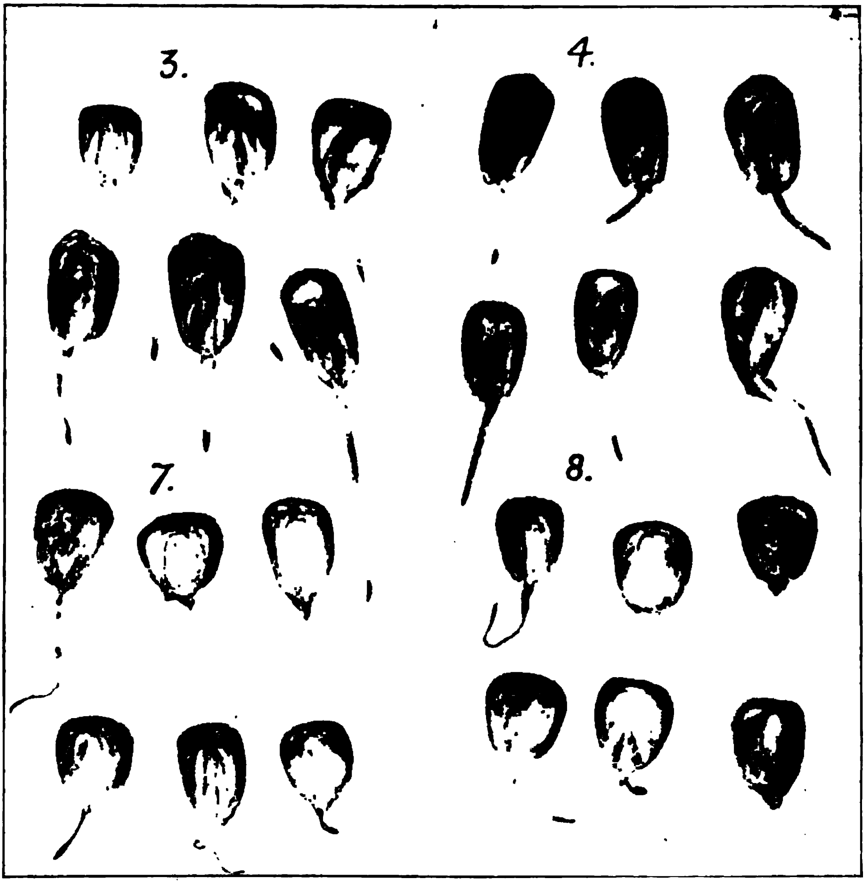

FIG. 3.—*Four squares from a germination box; 3, good vigorous germination; 4, medium good germination; 7 and 8, slow poor germination.*

After all the squares in the box are filled with the kernels from as many correspondingly numbered ears, a piece of thin cloth should be placed over them, being very careful not to disarrange or change the position of the kernels in putting the cloth down. This should be gently sprinkled with water and on top of this two thoroughly wet burlap

bags should be laid, care being taken to see that the burlap is pressed down closely at the corners and along the sides in order to keep all the kernels uniformly moist. The box should now be placed near a stove, where it is warm and where the temperature never goes below freezing. The kitchen is usually a good place. The bags on the top of the box should be sprinkled if there is any danger of their drying out.

Within from four to seven days, depending to a great extent on the temperature at which the germinating box is kept, the kernels will have germinated sufficiently to allow the selection of the ears to be made. The bags and piece of cloth should be taken off with great care so that the corn will not be disturbed. The kernels of each square should now be examined in connection with the ear from which they were taken and compared with the germinating kernels of the other ears. Great differences will be at once apparent. Some ears will be represented by kernels part of which as in ear No. 8, Fig. 3, show no germination. All such ears should be discarded. Other ears will be represented by kernels, which, as in No. 7, Fig. 3, germinate weakly. The roots will be thin, yellow and sickly, and perhaps some kernels will be mouldy and by their appearance as a whole show clearly lack of vigor. Those ears, all, or part of whose kernels germinate weakly, should be discarded. The kernels of still other ears will germinate vigorously with strong, healthy sprouts, as is the case in ears No. 3 and 4, Fig. 3. Ears represented by such kernels should be used for planting.

If it is found necessary to buy seed corn in bulk, ask your seed merchant for a sample and test several hundred kernels of this in a germinating box similar to the above. A germination test of such bulk samples can also easily be made by putting a piece of blotting paper in the bottom of a pan, thoroughly moistening this and putting the kernels on it. Now cover with some more wet blotting paper or wet cloths and place a pane of glass over the top of the pan to prevent drying out Keep the blotting paper and cloths damp. Examine at the end of five or six days. If less than eighty out of one hundred kernels germinate vigorously, it cannot be considered good seed corn.

Every farmer in the State should test the germination of the corn he plants for seed. This is especially important with seed intended for next year's planting. The work had best be done on some of these winter evenings before the spring work begins. Let the boys and girls do it. It will do them good and make the corn crop larger.

CARE OF SEED CORN.

When to harvest seed corn.—It is important that the seed corn be thoroughly dried out before it is subjected to severe freezing. It is desir-

able to select the seed corn early in the fall, before there is danger of freezes. Light frosts would not injure the seed, but the selection should not be delayed too long, as a severe freeze might greatly injure the vitality of the seed if it was not thoroughly dried out when the freeze came.

Where to gather seed.—Select your seed from that portion of the field which is uniformly the best developed. It is a good practice to husk this portion of the field early in the season to be sure that those ears saved for seed will have been husked and preserved before freezes occur.

How to preserve seed.—The seed corn as soon as husked should be placed in a dry, well-ventilated room where the ears can be spread out. They should not be piled in a heap, as it is important to expose them to a free circulation of air, so that they will dry quickly and thoroughly without moulding. It is a good practice, often followed, to leave a few husks attached to each ear, so that the ears may be tied together in pairs by means of the husks and then hung over poles or wires in the upper part of the room. If convenient, racks can be made like bookcases, with slat shelves about 4 or 5 inches apart, and open backs and fronts, in which the ears can be arranged until thoroughly dried. Only one row of ears should be placed on each shelf. This method allows the preservation of a large amount of seed corn in a small space.

Use of artificial heat in drying seed.—It has been found to be very important to dry out the seed corn quickly and thoroughly, and the use of some artificial heat is in most cases desirable. It is thus important, especially in damp, cold seasons, to place the seed corn in a room where there is a stove in which a fire can be maintained at least a portion of each day for about two weeks, or until the corn is thoroughly dried out. In favorable dry autumns artificial heat may not be necessary, but in many cases the "kiln drying" of seed, as it is called, will be found to be very important. In one experiment made by Mr. C. P. Hartley, of the U. S. Department of Agriculture, kiln-dried seed gave an average yield of 16 bushels per acre more than ordinary air-dried seed of the same variety grown in the same place. The experimental field in this case contained about 10 acres, and was planted with the air-dried and kiln-dried seed in alternate rows.

NOTE.—Correspondence on this subject may be addressed to Professor H. J. WEBBER.

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CORNELL UNIVERSITY

AGRICULTURAL EXPERIMENT STATION OF

THE COLLEGE OF AGRICULTURE

Department of Plant Pathology

FUNGICIDES.

BY H. H. WHETZEL.

Fungicides consist chiefly of chemical substances of a more or less poisonous nature that are applied to plants in various ways to protect them, or free them, from their fungous parasites. In far the greater majority of cases, the fungicide is to be applied to healthy plants to protect them from the attacks of these parasites. The fungicide must be of a kind or strength not injurious to the plant to be protected, but at the same time it must be destructive to the fungus spore that would germinate and infect the unprotected fruit or leaf. Because certain chemicals or certain strengths of these chemicals in solution are injurious to some plants and not to others and because not all parasites are affected alike by the poisons, different mixtures of different strengths must be applied to different plants. The stage of growth or development of the plant, the conditions of the weather, the life habits of the parasite to be destroyed and other factors, are almost always to be taken into consideration in applying fungicides to prevent diseases. We are rapidly learning that Bordeaux is not a "cure all" for all diseases to which plants are subject. We are also learning that the same strength of the mixture cannot be used with safety on all crops. It constantly becomes more apparent that other factors beside spraying play a very large part in the control of fungous diseases, none perhaps more so than *sanitation:* i. e. good and proper cultural methods; clean cultivation; thorough systematic pruning; proper rotation; yards, waste lands and fence rows kept free from weeds and volunteer plants. These are really the things that count most in the yearly fight against fungous pests. It is a significant fact that it is in the otherwise well-cared for orchard that spraying pays best.

In the case of a few fungi, such as surface mildews, the fungicide may be effectively applied after the parasite appears on the host plant. In the vast majority of cases, however, the parasite works within the host and the poison must be applied before infection takes place.

In some cases the fungicide is to be applied to the seed in order to destroy the spores that cling to the outside of it. In the case of a few diseases, the parasite enters the seed before it ripens and there remains dormant from one season to the next. The application of high temperature by means of hot water has proved effective in destroying the parasite without serious injury to the germinating ability of the seed. The loose smut of wheat and the naked smut of barley are good examples.

In a few cases, the application of certain chemicals to the soil effectively controls diseases of the roots or stems of plants. The few parasites controlled in this way are soil lovers, living for at least a part of their lives as saprophytes on the decaying materials or humus of the soil. Some soil fungi are effectively destroyed by steam sterilization. This is practicable chiefly in the greenhouse.

The preparation of the common fungicides is neither difficult nor expensive. Below are given concise directions for preparing those most commonly in use at present, together with lists of the more common diseases which careful experiments have shown to be effectively controlled by them. For detailed directions for applying them to any particular disease, address an inquiry to the Plant Pathologist, New York State College of Agriculture, Ithaca,N. Y.

SPRAY MIXTURES.

BORDEAUX MIXTURE.

Materials. Copper sulfate (blue vitriol) costing 7 to 10 cents per pound; good stone lime costing around a dollar a barrel; and water. These are to be put together in different proportions depending upon the crop to be sprayed and the time when the application is to be made. The proportion is usually expressed in the following way. 5–5–50 which means: Copper sulfate 5 lbs.; lime 5 lbs.; and water 50 gallons. Other proportions are used for some diseases and under certain conditions. These are indicated by other numbers in the formula, as 2–4–50, etc. The copper sulfate is the active agent in the mixture. The lime is added to neutralize the caustic action of the copper sulfate which would otherwise burn the leaves or fruit of the plant.

FORMULA 5–5–50.

To prepare the mixture. Dissolve the 5 lbs. of copper sulfate in 30 or 40 gallons of water by suspending the crystals in a gunny sack just beneath the surface of the water, as the dissolved vitriol settles quickly to the bottom. Prepare the lime (5 lbs.) by slacking it with hot water adding the water slowly so that the lime crumbles into a fine powder. When completely slacked, i.e. entirely powdered, add 5 or 6 gallons of cold water to make a rather thin milky solution. When the vitriol is all dissolved stir it thoroughly and pour into it the lime milk which has been thoroughly stirred. Add enough water to make 50 gallons. One solution, preferably the copper sulfate as indicated above should always be much diluted.

Never pour together two strong solutions and then dilute afterwards. Never pour together the two solutions until ready to use. It is well to strain the mixture as it goes into the sprayer to take out anything that might clog the nozzle. Do not use tin or iron vessels in making the bordeaux. They will be eaten by the copper sulfate.

When large quantities of Bordeaux are to be made, prepare *concentrated* stock solutions by dissolving the copper sulfate at the rate of one pound to the gallon and slake the lime, one pound to the gallon of water. Dilute 5 gallons of the vitriol solution in 30 or 40 gallons water and add 5 gallons of the lime solution. Add water to make 50 gallons.

When only a small amount of the mixture is wanted at a time prepare *dilute* stock solutions, by dissolving 5 lbs. copper sulfate in 25 gallons of water, and slake 5 lbs. of lime and dilute to 25 gallons in water. Now to prepare any desired amount of the mixture, stir the solutions thoroughly and pour together equal parts of each into a third vessel or in the sprayer tank. Stock solutions should be kept in barrels with tight lids to prevent concentration by evaporation.

Ferrocyanide test. It is not necessary to weigh the lime, if some test is used to determine when sufficient of the lime milk has been added. The most convenient test is the "ferro-cyanide" test. Put an ounce of yellow prussiate of potash in a pint bottle and fill it with water. This is poison and should be so labelled. Stop the bottle with a cork from one side of which has been taken a V shaped piece so as to give a small opening into the bottle. Add lime milk to the copper sulfate solution until the ferro-cyanide solution will not turn brown when dropped from the bottle into the mixture. Then add an extra gallon or so of lime milk. An excess of lime will do no special harm and may aid in some cases in holding the mixture to the plants or possibly prevent spray injury.

The following common diseases are controlled by Bordeaux mixture: Apple Scab, New York Apple-Tree Canker, Asparagus Rust, Bean Anthracnose (in some cases), Leaf-spot of Beets, Leaf-Blight of Celery, Leaf-spot of Cherry, Cucumber Mildew, Leaf-spot of Currant, Ginseng Blight, Black Rot of Grapes, Anthracnose and downy Mildew of the Grape, Hollyhock rust, Onion Mildew, Leaf curl of the Peach, Leaf-spot and Scab of the Pear, Leaf-spot of the Plum, Late Blight of Potatoes, Leaf and Fruit-spot of the Quince, Raspberry Anthracnose, Black-spot of the Rose, Strawberry Leaf-spot, Leaf-spot of Tomato.

In applying Bordeaux to some plants, it is desirable to add something to the mixture to make it adhere satisfactorily. The following has been useful in spraying such plants as onions, cabbage, asparagus, etc. By the use of this "sticker" the effectiveness of the mixture on other plants would perhaps be greatly increased and the number of applications in some cases reduced.

RESIN SAL SODA STICKER.

Resin	2 lbs.
Sal Soda (crystals)	1 lb.
Water	1 gal.

Boil in an iron vessel until of a clear brown color 1 to 1½ hours. Cook in the open and watch carefully as it is apt to boil over. For spraying plants like cabbage, onions and the like, add this amount to 50 gallons of Bordeaux, for spraying other plants add half the amount to 50 gallons of the Bordeaux. Bordeaux containing this "sticker," once dry, will not be washed off by the heaviest rains.

BORDEAUX INJURY.

Some plants are injured by the ordinary strength of Bordeaux even when properly made. Others like the apple are sometimes injured by quite weak Bordeaux under certain weather conditions. The leaves of most varieties of stone fruits, especially peaches, and Japanese plums are almost sure to be injured by Bordeaux except in very weak mixtures. The injury to these plants consists usually of small holes in the leaves, very similar in appearance to the shot hole effect of certain fungi. The injury on the apple occurs on both the leaves and the fruit. On the leaves it consists of quite definite brown spots very much like certain leaf spots due to fungi. Where the injury is quite severe the affected leaves turn yellow and fall. The injury on the fruit takes the form of russeting. It may even cause large cracks to appear. Some varieties of apples suffer more than others. Wet weather during the spraying season appears to be one of the chief factors in the production of Bordeaux injury. on apples. It has also been shown that "the more copper sulfate, the greater the injury." It is to be understood, however, that injury from Bordeaux is much less common and serious than injury from the scab, to prevent which it is applied. For fuller discussion of this subject see the N. Y. (Geneva) Bull. 287.

Good nozzles (hole 1-16 in.), good pressure (100 to 140 lbs.) and a good man, make spraying pay. Thoroughness is the secret of successful spraying. Be thorough.

SODA BORDEAUX.

Soda (Commercial lye), about	1½ lbs. (acc'd to strength)
Copper sulfate	5 lbs.
Lime, about	½ lb.
Water	50 gals.

Dissolve the copper sulfate in 30 gallons water; dissolve the lye in a gallon or so of hot water, dilute to 15 gallons and pour slowly into the copper sulfate solution. Add milk of lime to test with litmus or ferro-cyanide and add water to make 50 gallons. This mixture is rather difficult to prepare as there must be neither an excess of copper sulfate or of the lye. The lye must be of such strength that 1½ lbs. will not quite neutralize the 5 lbs. of copper sulfate. The small amount of lime is added to completely neutralize the copper sulfate. It is a colorless mixture and desirable as it will not clog nozzles. Should be used with caution for unless properly made will injure foliage severely. See N. J. Bulls. 167 and 194.

AMMONIACAL COPPER CARBONATE.

5-3-45.

Copper carbonate	5 oz.
Ammonia (26° Beaume)	3 pts.
Water	45 gals.

Make a paste of the copper carbonate with a little water. Dilute the ammonia in seven or eight quarts of water. Add the paste to the diluted ammonia and stir until dissolved. Add enough water to make 45 gallons. Allow it to settle and use only the clear blue liquid. This mixture loses strength on standing. Used in place of the Bordeaux where one wishes to avoid staining maturing fruits or ornamental plants. Not considered to be as effective as the Bordeaux.

CLEAR COPPER SULFATE SOLUTION.

Made by dissolving copper sulfate crystals in varying amounts of water depending upon the disease to be sprayed for and the time or season when the application is to be made. Usually applied to more or less dormant trees. 2 lbs. to 50 gallons is effective against Peach Leaf Curl. Should not be applied to plants in foliage.

POTASSIUM SULFID.

Potassium sulfid (Liver of sulfur),	3 oz.
Water	10 gals.

Make just before using, as it loses strength on standing. Particularly valuable for the powdery mildews of plants. Effective for the control of the following: Carnation Rust (1 oz. to 1 gal.), Gooseberry Mildew, Cherry Mildew, Phlox Mildew, etc.

SULFUR.

This is often effectively used in the control of Mildews. It is dusted thoroughly over the plants especially when they are wet. Most effective in dry hot weather. In Rose Houses it is mixed with half its bulk of lime and made into a paste with water. This is painted on the steam pipes. The fumes destroy the mildew on the roses. Mixed with lime it has proven effective in the control of onion smut when drilled into the rows with the seed. Also shown to be effective in preventing potato scab on infested land. Scatter in furrow at planting 300 lbs. to an acre.

LIME.

Not usually effective as a fungicide. Has been used as spray to prevent leaf curl of peach. Liming the soil with stone lime 2 ½ to 5 tons to the acre has proven very effective in controlling the club root of cabbage and turnips. Apply at least 3 months before planting the crop. 1 to 4 years is better.

LIME-SULFUR WASH.

The lime and sulfur wash used in spraying for San Jose Scale is also quite effective as a fungicide especially in preventing leaf curl of peach. A modified form of this wash known as the "self cooked" lime-sulfur wash is now being recommended for the spraying of peaches, plums, apples, etc., in foliage. It is said to cause no injury to the leaves or fruit. It has given good results in controlling Brown Rot and Scab of peaches. It is prepared as follows:

Place ten lbs. of sulfur and 15 lbs. of stone lime in a barrel. Add hot water slowly to slake the lime, keeping the mass wet but not submerged. Stir occasionally. Part of the large lumps of lime may be kept out at first and added after slaking has progressed to some extent, thus prolonging the slaking and heating. When slaked dilute to 50 gallons. Apply as you would Bordeaux.

SOLUTION FOR SEED TREATMENT.

FORMALIN.

This is a gas dissolved in water and comes of the strength of 40 per cent. Should cost about 30 cents a pint or pound. 1 pint diluted in 30 gallons of water is used effectively in preventing potato scab (soak tubers for an hour and a half

and plant in clean soil), or smut of oats and stinking smut of wheat (soak seed in solution for 10 minutes, drain and let it stand in sacks, 2 hours, dry or sow wet; or, sprinkle on grain as it is shoveled over on clean floor, 1 gallon per bushel, cover with blankets for 2 hours or more. Dry or sow wet.)

CORROSIVE SUBLIMATE.

This is a poisonous substance. Should be purchased in the powdered form. Dissolve 4 ozs. in 30 gallons water. Effective as a preventive of potato scab (soak tubers 30 minutes, allow to stand in sacks overnight). The same strength solution should be used in disinfecting wounds made in pruning out blight or cleaning out cankers on pear and apple trees.

HOT WATER.

This is used effectively in preventing the loose smut of wheat and the naked smut of barley. Immerse the sacks of grain in cold water for 12 hours. Drain one hour. Immerse in hot water at 130° F. for ten minutes. Plant at once. Use one-half more wheat to make up for grain killed.

OTHER MEANS OF CONTROLLING PLANT DISEASES.

As pointed out in the introduction there are things other than Fungicides that are of the utmost importance in controlling plant diseases. Often the value of the application of the fungicide is largely determined by the condition and environment of the sprayed plants. Some of the most important of these may here be considered.

Sanitation

This simply means the "cleaning up" of the premises, the yard, the orchard, the fields and fence rows; keeping the weeds down and the soil cultivated.

Pruning. An orchard of trees full of dead limbs and branches hardly offers the most satisfactory condition for effective application of spray mixtures. Carefully cut out all dead limbs and unnecessary branches. Open up the tops and let in the light and air. Trim out the water sprouts, clean out the cankers. Treat all wounds with the corrosive sublimate solution and paint with a good lead and oil paint. Repeat the painting once or twice a season until the wound is healed.

Burn the brush. Many of our fungous enemies mature and spread as readily from this fallen brush as if it had remained on the tree. Often a few days delay, especially in the spring, may suffice to ripen and disseminate the spores, thus largely undoing the work of pruning, Prune early and burn the brush at once. The pruning out of such dead and diseased limbs removes a great number of sources of infection and thus reduces the chances of infecting the healthy limbs and so directly assists the fungicide in controlling the trouble.

Destruction of diseased plants and plant parts. This practice is of far more importance than is usually accorded it. We well appreciate the necessity of quarantining or destroying animals affected with contagious diseases. Most plant diseases are contagious. Remove the wilted cucumber vine and burn it as soon as discovered. Remove the smut from the corn and destroy it. Never let it go into the manure. Cabbage and turnips affected with club root must never be fed to animals unless boiled thoroughly. Do not throw these diseased plants on another field or the manure pile. You are thus only spreading the disease. Cut the knots from

the plum tree and *burn them at once*. They should be cut not only from your own trees but from your neighbors. The wind carries the disease. Pick the old dry "mummy" plums and peaches from the trees during the autumn or winter and *do not throw them on the ground*. This is only wasting your time. The Brown Rot fungus will mature its spores on these mummies on the ground as readily as if they remained on the trees. Put the plums in a bag and carry them off and *burn them*. Gather up those that have already fallen to the ground and treat in the same way. When picking peaches, always pick and destroy all rotten ones. This is even more important than picking the healthy ones. The rotten potatoes, turnips, cabbage, etc., from the cellar or store house should not be thrown back on the fields or manure pile. They may be of some value as fertilizer but they are dangerous to succeeding crops. *Burn or bury them.*

Cultivation. The relation of cultivation to the control of plant disease is not generally appreciated. In many diseases like potato scab, black rot of cabbage, club root, etc., *crop rotation* is often the only means of eradicating the disease. The careful and systematic destruction of weeds not only in the crop but along the fences and road sides has a direct effect in keeping down certain fungi and bacteria that live upon these weeds, as well as on the cultivated crop. Oftentimes weeds and grass serve to hold moisture in places where it will be favorable to the development of certain diseases. This is strikingly true of the black rot of grapes. The fungus is carried over in the old mummies that fall to the ground. These lying among the weeds and grass that is often allowed to grow up beneath the vines, find here a more or less constant supply of moisture throughout the season, enabling them to mature and scatter their spores to the lower leaves and fruits. Keep the weeds and grass down by cultivation and the "mummies" are unable to mature spores. Burying the diseased grapes by early plowing and scraping from beneath the vines into the last furrow with a horse hoe is another practice to be recommended. The time at which cultivation is done is sometimes an important factor. For example every bean grower knows that beans should not be cultivated when wet. He does not usually know however, that this is due to the fact that the spores of the fungus are scattered only when wet. From this it appears that intelligent cultivation must take into consideration the diseases with which the crop is apt to be attacked. A knowledge of the conditions favoring the parasite as well as of those needed by the crop will be essential. *Know the crop but know its diseases also.*

Seed selection

It is well known that seed selection is one of the most important factors in maintaining the vigor and productiveness of many crops. Its importance as a *means of controlling plant diseases* becomes more evident every year. Evidence is constantly accumulating which indicates that many of our common diseases are regularly and chiefly carried over from one season to the next in the seed. The smuts of our cereal crops, the scab of potatoes (on tubers), the blight of peas, bean blight and bean anthracnose are a few of the examples. In the case of some of these seed selection as a means of eradicating the disease is not practical; in others it seems to offer the easiest solution of the problem. Beans free from the anthracnose fungus will apparently grow a clean crop. But the disease cannot always be detected in the seed itself. You cannot sort out the diseased seed. You can however select pods that are free from the disease. Pods with no spots on them con-

tain clean seed. Loose smut of wheat is controlled with difficulty by seed treatment. The selection of seed from fields known to be entirely free from the disease offers the best means of combating this malady. The selection of seed, from certain plants in a crop that are unharmed or at least that suffer but slightly from a given disease is now receiving much attention by plant breeders and pathologists. The strain thus developed is know as a resistant strain or variety. Remarkable success has attended the efforts of a number of investigators along this line. This is a means of combating disease that is within the reach of every grower of crops, for this tendency toward resistance to disease appears to be quite commonly exhibited by individual plants in any crop when passing through a disease epidemic.

Don't neglect to spray and don't fail to spray thoroughly, but remember at the same time to keep your plants in proper condition to receive the most benefit from the spraying.

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CORNELL UNIVERSITY
AGRICULTURAL EXPERIMENT STATION OF
THE COLLEGE OF AGRICULTURE
Department of Dairy Industry

SOME ESSENTIALS IN CHEESE-MAKING.

By C. A. Publow.

To make cheese is a simple operation; but to make cheese of uniform fancy quality is one of the most difficult problems in the dairy industry. Many conditions, produced by bacteria, changes of climate and foreign agents, have their influence on the process of manufacture. In controlling these conditions, in order to produce cheese of the highest quality, five factors must be taken into consideration:

1. The raw material—pure, clean milk.
2. The building and its equipment.
3. The skill of the maker.
4. The direct process of manufacture.
5. The curing and subsequent handling of the cheese.

1. The Milk Supply.

We cannot here go deeply into the methods of caring for milk used in cheese-making. Suffice it to say that no milk product requires purer milk than does American cheddar cheese. The finished cheese can be no better than the raw material from which it is made. Perfect cleanliness is the secret of successful cheese-making.

2. The Building.

The building should be so constructed and equipped that everything used therein may be kept clean. There should be good drainage and a pure water supply. The curing room should be provided with some means of controlling the temperature.

3. The Maker.

No profession requires more careful and more skilled mechanics than does cheese-making. No business demands more responsibility and

intelligence. A successful cheese-maker must be quick to think and to act. He must know his work, and be able to apply his knowledge in controlling variations caused by climatic, bacterial and chemical agents. In beginning his daily work, a maker should have clearly in mind the ideal in the finished cheese, and should conduct his work with this end in view. This ideal should be perfection; and this demands a knowledge of all the qualities required in a perfect cheddar cheese.

4. THE MANUFACTURE.

Cheddar cheese should have a neat, clean, attractive appearance, when cut, it should show a close solid, uniformly colored interior. It should have a clean, pleasant, mild aroma and a nutty flavor. It should possess a mellow, silky, meaty texture, and when rubbed between the thumb and forefinger should be smooth and free from hard particles. To make this kind of cheese, we must have milk of good quality. The following directions will apply only to the making of cheese from clean sweet milk.

Ripening the milk.—It is necessary that the milk be heated to 86 degrees Fahr., and that it contain a certain amount of acid before the rennet is added. The amount of acid is increased by allowing the milk to stand at the above temperature, or by adding a starter to the milk, or by both.

Adding starter.—One-half to two per cent. of good commercial starter may be used, depending on the sweetness of the milk. Too much starter causes an acid or sour cheese.

To determine acidity.—The acid in the milk is determined by an acidimeter. When there is .20% acid in the milk, it is ready for the rennet. At this time a Marshall rennet test will be 2½ spaces.

Adding color.—If colored cheese is to be made, the quantity of color used will depend on the requirements of the market to be supplied. Generally, ¾ oz. to 2 oz. per 1000 pounds of milk is sufficient. About 1 oz. per 1000 pounds makes a very desirable color for most markets. The color should be added to the milk *after adding the starter*, and be evenly stirred through the milk to insure a uniform color in the curd.

Adding rennet.—Enough rennet, diluted in cold, pure water, should be used to coagulate the milk firmly in 25 minutes. Generally, 2 to 4 oz. is necessary for every 1000 pounds of milk. Four to five minutes should be taken in stirring it in.

Cutting.—When the coagulated milk (curd) will split evenly ahead

of the finger, it should be cut as follows: Cut slowly lengthwise of the vat with a $\frac{3}{8}$-inch steel horizontal knife, having sharp edges. Then cut crosswise of the vat with a $\frac{5}{16}$-inch perpendicular wire knife. Finally, cut lengthwise of the vat with this same wire knife. The cubes resulting should be of uniform size to insure uniform development of acid, moisture and color in the curd and in the cheese. Losses are commonly found in the whey, due to carelessness or inability in the cutting or in the subsequent stirring. The knife should be drawn straight and even, and it should not overlap the previous cut. Many makers cut too fast. The faster the cutting, the smaller and more uneven the cubes will be.

Stirring.—This is only to keep the particles separated from each other and not to harden the curd, as many makers think. The cubes of curd are very tender and easily injured. If the stirring is roughly done, small pieces are broken off, which go back into a milky state and run away in the whey, resulting in serious decrease in the quality of the cheese. After the cubes are healed over, the stirring may be more active.

Heating.—After stirring for 15 minutes, the temperature should be raised to 98 to 100 degrees in 30 minutes. It is best to raise the temperature about 2 degrees every 5 minutes. Heat alone does not firm the curd. The curd is firmed largely by the effect of the acid, which causes it to contract and expel the moisture. The faster the acid is developed, the faster will the curd contract. Accompanying the contraction by heat retains the firmness and prevents reabsorption of whey moisture.

Rule for heating.—When the acidimeter is used for testing, the following rule is a reliable guide in heating: If after cutting, the whey around the curd shows

.14%	acid,	allow	30	minutes	for heating.
.145%	acid,	"	25	"	"
.15%	acid,	"	20	"	"

Heating too fast hardens the outside of the curd and prevents the escape of moisture. The acid develops from the whey *in* the curd and *not* from the whey *around* it, so that if too much moisture is retained in the curd, the acid develops too fast and an acid or sour cheese results.

The most important step in cheese-making is to have the curd firm in the whey before the required amount of acid has developed. A large majority of the acid or sour cheese are caused, not by the maker having given too much acid, as shown on the hot-iron test, but because the curd was too soft when that acid developed. One-sixteenth inch (.16%) acid will make a sour cheese if it develops on a very soft curd and too much

moisture is retained, while, on the other hand, a dry curd may stand ¼ inch (.22%) acid without serious bad effects.

Removing the whey.—The whey should not be removed until the curd is firm and springy, so that when a quantity is squeezed between the hands it will spring apart. Generally it takes two to three hours from the time of adding the rennet to have the curd in this condition. When firm, the curd should draw ⅛ of an inch of fine threads when rubbed on a clean hot iron. The whey around the curd should have .165% to .175% acid, as shown by the acidimeter. This will have to be varied slightly, depending on the time required for the running of the whey. The most accurate rule to follow is to have .24% of acid in the whey running from the curd after it has been stirred dry enough and piled up for cheddaring. This means about ¼ inch on the hot-iron test. It is a good practice to run the whey down to the level of the curd in the vat a few minutes before sufficient acid has developed. This gives better control over the remainder.

Stirring.—The proper place to stir and dry a curd is in the whey, from the time the whey has reached the curd level until it is all removed. This gives a brighter and better color to the curd and is easier than if stirring is delayed until all the whey has been removed. Too much free moisture should not be left around or in the curd at this time, as it causes acid to develop too fast.

Piling.—The curd should be piled along the sides of the vat, with drains between the piles.

Cheddaring.—As soon as the curd has become matted together sufficiently, it should be cut into strips six to eight inches wide, and turned over—the top strip going on the bottom. This takes 15 to 20 minutes from the time of piling. These pieces should be turned every 15 minutes until a good grain or texture develops. By this we mean that the curd will fibre out like the cooked meat on a chicken's breast. This fibrous condition can be hastened by piling the curd two or three layers deep each time at turning. At this time, the whey oozing from the curd will show .65% to .75% acid on the acidimeter, and when a piece of the curd is rubbed on the hot iron, fine threads will pull about 1 inch long.

Milling.—The curd should then be cut into small pieces of uniform size, by a curd mill. In buying a curd mill, it is advisable to get one in which the cutting is done by the knives going against the curd rather than one in which the curd goes against the knives. This causes less loss of fat from the curd.

Airing.—After milling, the pieces of curd should be well stirred, kept apart, and freely exposed to fresh air.

Salting.—After the pieces of curd have become well contracted and shrunken, with a silky mellow feeling, they are ready to be salted. The curd will now show about 1½ inch on the hot-iron test, and the whey oozing from the curd will show .90% to 1.% acid on the acidimeter. Generally, 1½ to 2½ pounds of salt per 1000 pounds of milk is sufficient. The more salt used the drier will be the cheese. The salt should be evenly distributed over the curd in at least three applications, accompanied by plenty of stirring. There should be no lumps in either the curd or the salt.

Hooping.—As soon as the salt has all been taken up by the curd and it has become mellow and has cooled to about 85 degrees Fahr., it is ready for hooping.

Pressing.—The curd should be weighed into the cheese hoops to insure uniformity in the size of the cheese. Pressure should be light at first, and be gradually increased. Cheese should remain in the presses at least 18 hours, and preferably 42 hours.

Dressing.—Too much care cannot be taken in finishing a cheese for market. It should be ready to dress within 30 to 45 minutes after pressure is first applied. Then the bandages are pulled up and made free from wrinkles, and trimmed to about one inch on each end. Plenty of hot water and clean soft press cloths should be used to insure a good rind on the cheese. The cheese will have a better finish if it is turned in the press the following morning. The appearance of a cheese is a good indication of its quality.

5. THE CURING AND SUBSEQUENT HANDLING.

Cheese is really only half made when it enters the curing room. From that time it has to change from a green indigestible product to a fully ripened palatable and nutritious food. If conditions are not favorable for a proper ripening, the quality of the cheese is injured. The best temperature for ripening is 50 to 55 degrees Fahr., and it should be uniform. The first week in the life history of a cheese is the most important period in determining its quality, and conditions should be made favorable during that time at least. The room should have good ventilation and a good circulation of pure air.

Care of curing room.—The cheese shelves should be washed frequently with boiling water containing a good washing powder, rinsed with hot

salt water, and placed in sunlight to dry. This keeps the ends of the cheese clean and helps to prevent mould. The cheese should be turned on the shelves every day.

Paraffining.—When cheese is to be paraffined before shipping, the paraffining should be done when it is about five days old, with wax heated to 220 degrees Fahr. The cheese should be left in the wax for 8 to 10 seconds.

Boxing.—The boxes should fit the cheese snugly and be strong enough to stand shipping.

Branding.—The boxes should have the cheese weight neatly stenciled in the same place on each box. One should not use a pencil for marking on the weights, nor use shoe blacking for stenciling. A mixture of coal oil and lamp black makes the best material, and it will not become blotted. The weight should be placed in large figures, either directly under or on the right side of the factory brand, which should be small and neat. Cheese should not be consumed before it is at least eight weeks old.

DIRECTIONS FOR USING THE ACIDIMETER.

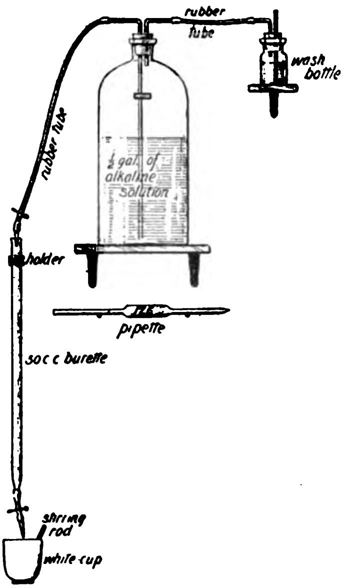
A. *Setting up the apparatus.*—This can be accomplished most easily by studying the drawing shown on page 23.

1. Screw the burette holder into the wall at a convenient height for reading. Then place the burette in the holder, small end down.
2. Arrange a shelf to hold the large bottle, in such a way that the bottom of the bottle will be on a level with the top of the burette.
3. Another shelf is required to hold the small wash bottle. This should be on a level with the top of the larger bottle
4. Connect the rubber and glass tubing as shown in the drawing.
5. The small bottle should be kept half full of the same solution as is used in the larger bottle. This is for washing the carbonic acid from the air which passes in through the glass tube to give pressure for siphoning.
6. On the large bottle a mark has been filed. Empty the contents of the small bottle, labeled "alkali," into the large bottle, rinsing it with soft water so that all the alkali is removed. Fill the large bottle up to this mark with clean soft water; shake the large bottle to insure a thorough mixing of the alkali.
7. To start the siphon: Have corks tight in bottles. Loosen clamp on rubber tube and by aid of the mouth draw the fluid up until all air in

the tube is replaced. Then allow the clamp to tighten. On loosening the clamp again, the solution will run into the burette.

8. The small dropper-bottle contains a solution of phenolphthalein.

B. Making the test.—Measure with the pipette 17.6 c.c of the substance (milk, whey, cream or starter) which you wish to test, and place it in the white cup. Add two drops of the phenolphthalein solution. Then allow the alkaline solution to run into the cup from the burette, one drop at a time, until the fluid in the cup, which is being constantly stirred, shows a very faint pink color. By reading the graduations on the burette we can ascertain the amount of acid in the substance tested. Each cubic centimeter of alkali used represents .01 % of acid in the fluid.



C. Amount of acid to be developed at each stage.—In cheese-making.—

.20 to .21 % before adding rennet.

.14 to .145% before cooking.

.16 to .18 % before removing whey.

.22 to .24 % when all whey is removed and curd is packed.

.65 to .75 % before milling.

.90 to 1.10% before salting.

.70 to .80 % in starter.

In butter-making.—The acidimeter is a great help in securing a uniform flavor in butter. The amount of acid should vary with the amount of butter-fat in the cream.

% fat.	*% acid.*
20	.72
30	.63
40	.54
50	.45

D. Precautions.—

1. Do not place the colored solution in the sunlight.

2. Do not use any solution that has been in the burette over night. It will have lost its strength.

3. Keep corks tight.

4 Great care is necessary in detecting the first change in color. This is made easier by holding the fluid being tested over the large volume from which the sample has been taken.

5. Temperature of the milk, whey, etc., has no influence on the result of the test.

6. Always be accurate in measuring with the pipette, and clean it each time after using.

7. Use all your tests and special senses. The acidimeter is the best acid measure we have, and if carefully used is most reliable; but errors will result from carelessness and inability of the user.

CORNELL
Reading-Course for Farmers

PUBLISHED MONTHLY BY THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY, FROM NOVEMBER TO MARCH, AND ENTERED AT ITHACA AS SECOND-CLASS MATTER UNDER ACT OF CONGRESS, JULY 16, 1894.
L. H. BAILEY, DIRECTOR. CHARLES H. TUCK, SUPERVISOR.

SERIES VIII. MISCELLANEOUS. | ITHACA, N. Y., NOVEMBER 1907. | No. 36. AGRICULTURAL EXTENSION

AGRICULTURAL EXTENSION.

A WORD OF GREETING.

BY THE SUPERVISOR.

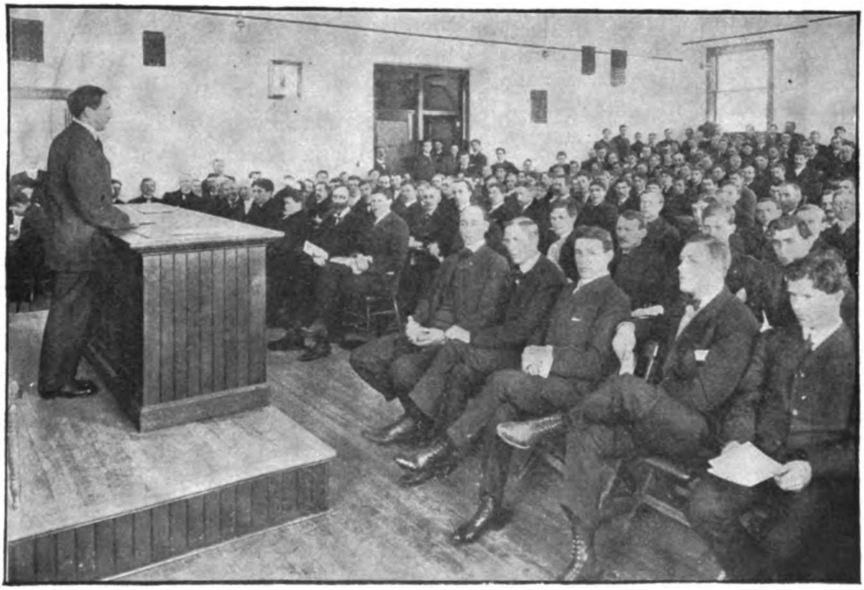


FIG. 370.—*A farmers' meeting in session at the College of Agriculture last winter.*

Another Reading-Course season has opened. The thirty regular Bulletins of the Reading-Course are available for study and discussion, being revised from time to time as the progress of information demands. Those persons who complete these series are taken into the reading of books, experiment station bulletins and other literature.

The College recognizes that its information cannot be of the greatest service if it is held within the confines of the class-rooms and laboratories. This correspondence course stands as a testimonial of the desire of the authorities to spread the light of really helpful information wherever there is just and reasonable need for it. So it is with feelings of pleasure

that the correspondence workers greet you, the readers, for another winter.

Reading-Course and Experiment Station Bulletins.

Our records show that some of the Reading-Course Bulletins have not been as largely utilized by our readers as they should be. Some of our best publications have not had the distribution that was their due. This we hope to remedy by calling your attention from time to time to the particular kind of helpful information which may be received from some of these bulletins hitherto not well known. The information in the bulletins remains sound year after year.

Not only have we Reading-Course bulletins for such distribution, but also Experiment Station Bulletins, a list of which appears on the back of this bulletin. These Station bulletins, somewhat technical in their nature, have to do with many agricultural problems in different parts of the State. To be sure, the use of certain of these bulletins is not so pertinent in some sections as in others. This winter we shall prepare a list of these bulletins in such a way that particular localities will be able to ascertain the information that is applicable to their place. All this will be arranged so that the quickest information will be furnished in the most useful way, at the least cost.

Advanced Correspondence Course.

After a reader has completed the Reading-Course bulletins up to date he is then ready for and should take the work that is known as the advanced Correspondence Course. This consists, primarily, of the reading of assigned books of well known authorities, on particular phases of farming. Some twelve or fifteen subjects have been prepared for this work. We can furnish you the names of the best books, together with the price and author. The longer one reads the bulletins, the more one is convinced that his work should be conducted in a more definite, systematic way, with such full and accurate information as can be secured in these well known books.

Traveling State Libraries.

It gives up pleasure here to repeat what was said last winted concerning the helpfulness that is offered by the Traveling State Libraries. The State Department of Education has arranged for distribution a large number of books which can be secured at a nominal rate for a reasonable period of time. Definite arrangements have been made, in particular, for the supplying of agricultural books to farmers. I suggest that each one interested write to this division of the State Education Department at Albany to arrange for the securing of these books at an early date.

The Clubs.

Today, more than ever before, the farmer realizes the advantages of organization. Now, we must not be afraid of this word "organization" because it may look a little formal to us. I mean by it, the mere getting together of neighbor with neighbor for the purposes of discussing, not only great political issues, but the simple affairs of one another's lives and work. It happens that farmers are engaged in a business which draws upon a large number of sciences — a business that affords opportunity for wide discussion, liberal thinking and careful application. All of this may be obtained, in the most helpful kind of a way, by small groups of farmers, their wives and children, coming together at one another's houses in simple, informal organizations known as Reading-Clubs. This question was taken up at some length in Bulletin No. 31, published last winter. Suffice it to say now that where this work has been undertaken, remarkably good results have been secured. The organizations, under such conditions, have not only been the incentive for securing information, but have been of definite value in creating a little social interest among the people. More than all, there is something in these Clubs that attracts and holds the attention of the young people. In this one point alone they have well proved their worth.

Lectures and Literary Entertainments.

The College is placing itself in a position in which it can co-operate with these Clubs, and with any other kind of an organization which endeavors to present in its programs helpful information on agriculture. It is preparing lecture series, of a popular nature, which will be not only entertaining for young people, but instructive for all. Lantern slides will be shown picturing scenes at the College and on actual farms in the State; literary and historical talks will be given, adding much to the attractiveness of the meeting. The titles of these lectures for Clubs will be published in the near future, with a definite statement of the arrangements that may be made with the College for the securing of the entertainment. In this way both the people and the College will come more closely together, resulting undoubtedly, in the mutual benefit of all.

Some of this work has found its expression in meetings held in country places near Ithaca. For some few years, students of the College have been conducting, with the co-operation of the neighboring farmers, meetings in nearby school houses and churches. There, questions of agricultural interests, relative to the particular locality have been discussed, not only by the students, but by the farmers. Questions have been freely asked back and forth. A popular entertainment has been furnished by

quartets of singers from the College. The work has progressed without serious interruption, in the face of many obstacles, to the point where today it is practically a fixture, both students and farmers feeling that the discontinuance of it would be a mistake. Wherever possible, at these meetings, the students have sought to co-operate with such entertainments as already had recognition in such places. For instance, they are glad to co-operate with a Sunday School entertainment, or a Grange meeting, or whatever may be recognized as an institution of local importance.

The managing of these experimental meetings, the presenting of talks at them, raised the important issue as to the fitness of the agricultural students individually to conduct the work. As a result of the recognition of this problem, a course of academic rank has been instituted at the College which purposes to train young men and women to recognize and meet the responsibilities and duties which will be theirs on entering the field of practical work, which will train them to present to the proper people in a plain, practical, useful way, the information that they may have acquired. These students are placed at the disposal of accessible meetings. Speakers from this class will be chosen by competition, only those being sent out who know the subject matter on which they are to speak, and who have some little ability to present that subject matter with persuasive force.

Not only are these students available to the people nearby, but we are now ready to say that in so far as our means will permit and the number of students will allow, this class is at the service of other organizations of farmers in the State. The student will be chosen with extreme care. He will have the advice of the expert in the department where he is working, and he will have the criticism of his fellow students, both as to his information and as to his way of presenting it. When all of this has been done, he will go out with the approval of the College, to give just what he gave in competition among other students at the College. He will be equipped with proper stereopticon apparatus to make his talk not only instructive, but interesting. He will be sent as much to secure information from your experience as to impart information to you. If you are interested, further details may be secured from the Supervisor.

The New York State Experimenters' League.

The desire of the people and the College to get together more closely is finding its expression in different ways. One of the most significant expressions of this growing bond of sympathy is represented in the New York State Agricultural Experimenters' League. For several years now this association has been at work proving its right to existence. The evidence of interest at the annual meeting last winter, held at the State

College, stands as sufficient testimony of the work that it can do. Seldom has there been an opportunity to attend a meeting where the intellectual tone and evident sincerity of purpose were more manifest than when the Experimenters came together last winter. The cut on the first page shows this meeting in session, with the President, Mr. Harry B. Winters, presiding. The students and the farmers are seen sitting together in the audience. The meeting represents definitely the college influence in agriculture.

The weakness of many agricultural organizations lies in the fact that there is not sufficient definiteness of purpose — there is not sufficient concrete subject matter presented on which the members can work. The Experimenters' League has remedied this defect to a large extent. The work of this League is conducted along several different lines. Dairying, poultry, horticulture, agronomy, plant diseases, entomology, and several other subjects come in for their share of attention, with experiments outlined, having for their ultimate purpose the securing of information that will make the man who works in close contact with these problems more able to help himself. The management of the League provides definite personal instruction in the execution of these experiments. Membership in this organization is open to every farmer or person who desires to carry on some kind of experimental work in agriculture. These experiments are not the scientific plans of the Experiment Station, but they are arranged so that full opportunity for the display of the farmers' judgment may be had.

League Prizes.

So much interest has been aroused in this League that a year ago prizes were offered for the best work done in different fields. Members of the League responded to those offers; several meritorious papers were presented at the League in competition for the prizes, the first prize going finally to a young man who had shown both practical experience and sound management.

At the meeting last winter enthusiasm ran high. Several men put themselves on record as desiring to increase the amount of the prizes. One hundred dollars finally were raised for this purpose. Anyone having either large or small experiments in his farming, if his membership in the League is paid up, is eligible for this contest. Further regulations may be had by writing to the undersigned.

Farmers' Week at the College.

But however great the results of the meeting of the League may have been, measured by its own standards, still greater was its influence to incite similar meetings of other organizations at the same time and place.

Inquires concerning the work have crowded in upon us in our correspondence; visitors coming to the College, both as individuals and as representatives of organizations, impressed us with the necessity of answering the demand of the people for a definite time during the college year when the whole institution might be thrown open for inspection, entertainment and instruction. It, therefore, gives us pleasure to announce that Director Bailey last spring set aside the week beginning February 17th, and ending the 22d, 1908, for a Farmers' Week. It is the natural outgrowth of the work of the Experimenters' League. There will be no need for credentials, yet organizations will do well to properly clothe their representatives with authority. Everyone is invited to come.

It is to be hoped, that the many different agricultural societies of all kinds will see fit to send delegates to this convention. Reading-Course Clubs can, at slight expense to their individual members, send a delegate to this convention, with his expenses paid. The same might well be done by many other organizations. Arrangements could be made to bring before these delegates representatives of the different State institutions and public corporations which have to do with farmers' interests. In this way, not only would a helpful co-operation be brought about, but the farmers would be able to present a solid influential front to those who are seeking to know their problems better.

The Program.

During this week the different departments of the College will be open for close inspection. Lectures and demonstrations will be given in connection with the different lines of work. A Poultry Institute will be in session during this week, practical demonstration being given along several lines. Practical lessons in judging dairy cattle will be given in the judging pavilion. All departments will contribute their share in carrying out this educational side of the work. Not only will there be technical lessons, but lectures with lantern slides of a general kind, both historical and literary, will be provided for the evenings' entertainments.

Special arrangements will be made for the return of all old students of the College of Agriculture, regulars, specials and winter-course men. Headquarters will be given to the different winter-course clubs. Boarding and lodging arrangements will be made easily accessible for all the visitors. Every effort will be made to make of this convention a pleasant and profitable week for all who may desire to come.

The Country School Teacher.

Everyone is appreciative of the great problem which faces the rural school teacher of today. In the general demands being made upon the

teacher for the introduction of agriculture in the rural school, one must appreciate that the teacher has not always had the facilities that should have been available for acquiring this knowledge. At this farmers' convention, a special program of instruction for rural school teachers will be presented, having for its purpose the interpretation in practical lessons of the agricultural work called for by the syllabus of the New York State Department of Education. That there is a desire on the part of teachers to attend such a meeting was shown by the talks that were given at the Experimenters' meeting last winter. Three teachers presented good addresses on rural school education. These addresses should have been heard by all the rural teachers of the State. In order that the demand for instruction on this subject may be satisfied, to a degree, the College of Agriculture will open all her public school teaching facilities at the time to the use of the rural school teachers.

On Friday evening of the week a general assembly of all the different clubs and visitors will be held in the large auditorium of the College. Here an address will be given by Director Bailey. Prominent farmers of the State will take part in a short program, which will then be followed by a social evening.

Details of the arrangements for the week, together with programs, may be secured by writing to the author of this article.

CHARLES H. TUCK,
Supervisor Farmers' Reading-Course.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE RESIDENTS OF NEW YORK STATE WHO MAY DESIRE THEM, AS LONG AS THE SUPPLY LASTS.

93 The Cigar-Case Bearer.
121 Suggestions for Planting Shrubbery.
129 How to Conduct Field Experiments with Fertilizers, 11 pp.
134 Strawberries under Glass.
135 Forage Crops.
136 Chrysanthemums.
137 Agricultural Extension Work, Sketch of its Origin and Progress.
139 Third Report upon Japanese Plums.
140 Second Report upon Potato Culture.
141 Powdered Soap as a Cause of Death Among Swill-Fed Hogs.
142 The Codling-Moth.
143 Sugar Beet Investigations.
144 Suggestions on Spraying and on the San Jose Scale.
145 Some Important Pear Diseases.
146 Fourth Report of Progress on Extension Work.
147 Fourth Report upon Chrysanthemums.
149 Quince Curculio.
150 Tuberculosis in Cattle and its Control.
151 Gravity or Dilution Separators.
152 Studies in Milk Secretion.
153 Impressions of Fruit-Growing Industries.
154 Table for Computing Rations for Farm Animals.
155 Second Report on the San Jose Scale.
157 Grapevine Flea-Beetle.
158 Source of Gas and Taint Producing Bacteria in Cheese Curd.
162 The Period of Gestation in Cows.
163 Three Important Fungus Diseases of the Sugar Beet.
164 Peach Leaf-Curl.
165 Ropiness in Milk and Cream.
166 Sugar Beet Investigations for 1898.
168 Studies and Illustrations of Mushrooms; II.
170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.
172 The Cherry Fruit-Fly; A New Cherry Pest.
175 Fourth Report on Japanese Plums.
176 The Peach-Tree Borer.
180 The Prevention of Peach Leaf-Curl.
182 Sugar Beet Investigations for 1899.
185 The Common European Praying Mantis; A New Beneficial Insect in America.
186 The Sterile Fungus Rhizoctonia.
187 The Palmer Worm.
188 Spray Calendar.
189 Oswego Strawberries.
190 Three Unusual Strawberry Pests and a Greenhouse Pest.
192 Further Experiments against the Peach-Tree Borer.
193 Shade Trees and Timber Destroying Fungi.
194 The Hessian Fly. Its Ravages in New York in 1901.
195 Further Observations upon the Ropiness in Milk and Cream.
196 Fourth Report on Potato Culture.
198 Orchard Cover Crops.
199 Separator Skimmed Milk as Food for Pigs.
200 Muskmelons.
206 Sixth Report of Extension Work.
207 Pink Rot an Attendant of Apple Scab.
208 The Grape Root Worm.
209 Distinctive Characteristics of the Species of the Genus Lecanium.
210 Commercial Bean Growing in New York.
212 Cost of Producing Eggs. Second Report.
215 The Grape Leaf-Hopper.
216 Spraying for Wild Mustard and the Dust Spray.
219 Diseases of Ginseng.
220 Skimmed Milk for Pigs.
221 Alfalfa in New York.
222 Attempt to Increase the Fat in Milk by Means of Liberal Feeding.
225 Bovine Tuberculosis.
227 Cultivation of Mushrooms by Amateurs.
228 Potato Growing in New York.
231 Forcing of Strawberries, Tomatoes, Cucumbers and Melons.
232 Influence of Fertilizers upon the Yield of Timothy Hay.
233 Two New Shade-Tree Pests.
234 The Bronze Birch Borer.
235 Cooperative Spraying Experiments.
237 Alfalfa—A Report of Progress.
238 Buckwheat.
239 Some Diseases of Beans.
240 The Influence of Mushrooms on the Growth of Some Plants.
241 Second Report on the Influence of Fertilizers on the yield of Timothy Hay.
242 Cabbages for Stock Feeding.
243 Root Crops for Stock Feeding.
244 Culture and Varieties of Roots for Stock Feeding.
245 Spray Calendar.
246 A Gasoline-Heated Colony Brooder-House.
247 The Importance of Nitrogen in the Growth of Plants.
248 New Poultry Appliances.
249 Comparison of Four Methods of Feeding Early Hatched Pullets.

Address, COLLEGE OF AGRICULTURE,
ITHACA, N. Y.

SUPPLEMENT TO

CORNELL

Reading-Course for Farmers

PUBLISHED MONTHLY BY THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY FROM NOVEMBER TO MARCH, AND ENTERED AT ITHACA AS SECOND-CLASS MATTER UNDER ACT OF CONGRESS JULY 16, 1894. L. H. BAILEY, DIRECTOR.

SERIES VIII. MISCELLANEOUS. | ITHACA, N. Y. NOVEMBER, 1907. | No. 36. AGRICULTURAL EXTENSION.

A Discussion-paper is sent out with all Farmers' Reading-Course Bulletins, for two reasons: (1) *We should like to have your own ideas on these subjects. On some of these points you have probably had experience that will be interesting and valuable to us. No matter what the Bulletin says, if you have different opinions on any of these subjects, do not hesitate to state them on this paper and give your reasons.* (2) *We should like you to use this paper on which to ask us questions. If there are any points which the Bulletin has not made clear or if there are any problems in your farming, whether on these subjects or others, on which you think we may be able to help you, write to us on this paper.*

THE NEXT READING-COURSE BULLETINS WILL BE SENT TO THOSE WHO RETURN TO US THIS DISCUSSION-PAPER, WHICH WILL BE AN ACKNOWLEDGMENT TO THE RECEIPT OF THE BULLETIN. *This paper will not be returned to you, but we shall look it over as carefully as we would a personal letter and write to you if there are any points about which correspondence is desirable. You may consider this discussion-paper then, as a personal letter to us. It will be treated as such, and under no circumstances will your remarks be made public. As the Discussion-paper will contain written matter, it will require letter postage.*

If you are not interested in this Reading-Course Bulletin, we have others on other subjects, and we shall be glad to send any of these to you on request. The titles of the six Series of the Reading-Course Bulletins now available are: 1. THE SOIL AND THE PLANT. 2. STOCK FEEDING. 3. ORCHARDING. 4. POULTRY. 5. DAIRYING. 6. FARM BUILDINGS AND YARDS. *Helps for Reading, in The Farmers' Wives' Reading-Course, on domestic subjects, is also sent to those who desire it.*

THESE BULLETINS CAN NOT BE SENT TO PERSONS WHO RESIDE OUTSIDE OF THE STATE OF NEW YORK, AS BOTH COURSES ARE SUPPORTED BY A STATE APPROPRIATION.

Now is the time to take a strong, sharp hold of reading and study for the winter. Clubs are to be organized; literary programs full of agricultural information must be prepared. In all this the College of Agriculture stands ready to help and be helped. Feel free to use its extension facilities as suggested in the bulletin.

Notice the Farmers' Week to be held in February. If you want to help, please fill out the following blanks:

What are your desires in the way of reading for this winter?

Do you want further information concerning Farmers' Week?

Give the names with the presidents' and secretaries' names and addresses of all agricultural organizations with which you are connected.

Name..

Date..

County .... Postoffice.......................

NOTE.— Your name appears on our mailing list as this Bulletin is addressed. If incorrect, please write us.

Address all correspondence to Farmers' Reading-Course, Ithaca, N. Y.

CORNELL
Reading-Course for Farmers

Published Monthly by the New York State College of Agriculture at Cornell University, from November to March, and Entered at Ithaca as Second-class Matter under Act of Congress, July 16, 1894.
L. H. Bailey, Director. Charles H. Tuck, Supervisor.

SERIES VIII. MISCELLANEOUS. | ITHACA, N. Y. DECEMBER 1907 | No. 37. DRAINAGE. Supplement to Bull. No. 2.

DRAINAGE AND LARGER CROPS.

By E. O. Fippin.

The first four bulletins in the Reading-Course series are devoted to the soil as a medium for plant growth. In the first bulletin, the general characteristics of soil are stated. In the third bulletin, the plant-food supply in the soil — its kinds, amounts and means of increase by the use of fertilizers and manures—is discussed. The fourth bulletin shows how the plant takes its food from the soil, and the second bulletin explains some of the ways in which the soil may be modified by means of tillage and drainage so that it will be a more congenial home for the plant. The discussion in these bulletins implies that the plant requires a number of things for its growth. It must have food, moisture, light, heat and air; and in addition all our common plants have root systems adapted not only to taking in food, but also to holding the plant in its normal position so that it can grow properly and naturally.

Fig. 371.—*Digging a main ditch by hand in stony soil.*

If just the right amount and kind of any one of these essential conditions for growth are withheld, the development of the plant is impaired. For example, if there is not enough food the plant will be small and stunted in appearance. A low temperature may hinder or even prevent the normal growth and development of the individual.

duction on a commercial scale at the New Jersey Experiment Station showed that when bran cost $22.50 per ton, the hay was worth $16.50 as a substitute for it. In this case Alfalfa hay was worth a little over two-thirds as much as bran.

Conditions affecting success with Alfalfa. The most frequent causes of failure are weeds, and lack of manure, lime or inoculation. Occasionally poor seed or dodder causes failure.

Varieties. In co-operation with the United States Department of Agriculture and with farmers we now have fifty variety tests of Alfalfa in this State. Half of these were started in 1906 and half in 1907. The work has not yet gone far enough to give final conclusions. In general it is much safer to secure seed from a region about as far north as New York. Seed from Kansas is doing well in the tests.

Seed. The seed should of course be alive and comparatively free from weed seeds. It is sometimes adulterated with bur clover, yellow trefoil and sweet clover. Dodder is the worst weed in the seed. Of 399 samples examined by the United States Department of Agriculture in 1907, about half (191) contained dodder.

Seed should if possible be purchased from regions where dodder is least prevalent. Before buying seed, a sample should be examined for dodder seed.

To tell if the seed is alive, place one hundred seeds on a moist piece of blotter paper on a pie pan. Lay another moist blotter over the seeds and place a piece of glass over the pan. At the end of a week count the seeds that have sprouted—85 to 95 % should sprout.

The beginner should sow at least twenty-five pounds of good seed per acre. Older growers whose soils are in shape for Alfalfa may sow twenty pounds. We recommend thirty pounds in the co-operative experiments.

Soil. Alfalfa is most likely to succeed on porous well drained soils but is fairly successful on some clay soils. The north half of Western New York contains large areas of soil that are well adapted to Alfalfa. There is probably no county in the State, with the possible exception of the Adirondacks, that does not have some areas that will grow Alfalfa.

During the past two years, 171 co-operative experiments in the growth of Alfalfa have been taken up by farmers in connection with the College of Agriculture. A large number of such experiments were conducted in previous years.

Sixty-three per cent of the experimenters report a successful field on some plot. In this connection it is interesting to note that the

Oklahoma Experiment Station estimates that not over one in five of the seedings in that state are successful.

On the hill lands of much of southern New York there are relatively fewer successes, but on well drained areas the crop is well worth a trial. In all parts of the State there are gravelly deposits along the stream courses that are well adapted to Alfalfa, Such soils should be sufficiently elevated to be comparatively free from floods. Many of the sandy soils of Long Island and Saratoga County can be profitably used for its growth.

Alfalfa will grow on nearly any well drained deep soil if given proper treatment, and grows successfully on many shallow soils.

Lime. Alfalfa is more likely to need lime than is any other common farm crop. It is more influenced by lime than is clover. Sixty-one per cent of the co-operative experiments showed the need of lime.

About fifteen hundred pounds per acre is a fair application. The lime is best applied as long before the seed is sown as possible.

Inoculation. Inoculation is absolutely necessary for success. Inoculation may take place naturally or may have to be applied. Soil from sweet clover will inoculate Alfalfa. Most of the cases of natural inoculation appear to be due to the previous growth of sweet clover on the soil. Common clover soil does not inoculate Alfalfa.

Even in fields that require inoculation for success, a few plants usually become inoculated from some source. These usually look large and dark green as contrasted with the small yellowish uninoculated ones. If such a field is planted and reseeded it is often well inoculated. It is therefore often desirable to make a new trial on ground where Alfalfa has thus failed.

Fifty-four per cent of the co-operative trials have shown the need of inoculation. The most successful way to inoculate is by applying soil from a good Alfalfa field or from a place where sweet clover is growing. This is sown on the field at the rate of about four bushels per acre. It is usually easiest to sow it by hand. The soil thus used should not be allowed to become dry before being applied as the bacteria are killed if they become dried. In applying the soil it is best to apply just before a harrowing. The liquid cultures have rarely been successful in New York.

So far as we know, Alfalfa and soy beans are the only legumes that require inoculation in New York. Alfalfa requires it on most soils, and we have not yet seen any soy beans with nodules that were not inoculated. The writer has examined clover roots on soils where clover fails and has always found nodules on the few plants that lived.

Manure. Alfalfa is a heavy yielding crop and requires a rich soil for best results. This is particularly true in the beginning. The manured plots have been best in most cases. In many cases manure has been absolutely necessary for success. Unless the land is rich enough to produce a large corn crop without manure, it should be manured for Alfalfa. Seventy per cent of the co-operative tests have shown manure to be essential.

If the land and the manure are not comparatively free from weed seed, the manure should be applied to a preceding tilled crop, such as corn or potatoes. Or better, apply it the year of seeding and carry on a summer fallow until the weeds are subdued, before sowing the Alfalfa.

In seeding some of the very sandy lands, it is usually desirable to apply a light dressing of manure that is free from weed seed just after seeding. This will protect the young plants from drouth and from the sun.

Weeds. Weeds are one of the most serious enemies of young Alfalfa. If a well tilled crop precedes Alfalfa the injury is likely to be less. A nurse crop keeps down weeds, but may be as hard on the Alfalfa as the weeds are. The nurse crop of small grain has one advantage, it dies when it is cut, while the weeds are not killed by cutting. The sure way to avoid weeds is to seed late after a summer fallow. Of thirty-seven trials of seeding before June 20th, seventeen were badly injured by weeds. Of seventeen trials of seeding after June 20th only three were injured by weeds.

Time to Sow. There are successful fields of Alfalfa that have been secured in all kinds of ways, but there are two ways that seem to be giving the largest proportion of successes.

The surest way to secure Alfalfa is to apply manure and plow in the spring, then harrow the land and keep the weeds down until they are subdued. After this is accomplished sow the Alfalfa at some time when the seed bed and moisture conditions are favorable. It may be sown from the last of June to the first of August. Sometimes it is sown after early potatoes with success. It is very doubtful if it should ever be sown alone in New York before the last of June.

If Alfalfa is sown in the spring it is best to seed it with barley, using only about one bushel of barley per acre. The barley should be cut for hay before it matures. Barley is better than oats because it shades the ground less.

Those who are growing Alfalfa successfully may keep on with present methods, but a beginner will do well to follow one of the methods outlined above, preferably the former.

In no case do we expect returns from Alfalfa the first year. The second method therefore gains nothing but the nurse crop. Statistics gathered from the Ohio farmers on this point are interesting. Fifty-nine reported that they had decided to change from seeding with a nurse crop to seeding alone, while only seven were expecting to change from seeding alone to seeding with a nurse crop.

Fifty-seven had decided to continue to seed alone but to do so later in the season. None who were seeding late were expecting to change to early in the season.

At the Ohio Station Alfalfa seeded on May 24th yielded 6600 pounds per acre the next year, that seeded July 6th and August 3rd yielded 9500 pounds.

The following Experiment Stations recommend seeding in late summer (not early fall), the date depending on the latitude: N. J., Ohio, Ala., Okla., Md., Mo., Ind., Cornell, Kan., N. C. Alfalfa thus seeded usually does not need to be cut the first year. If the growth is likely to be too heavy to allow on the land, it should be cut. If it needs to be cut it should be cut early enough to allow for a protecting growth for winter. A growth a foot high makes a good winter cover. If too much is left it may smother the plants. Clipping when the Alfalfa is small is often injurious.

Hay Making. Alfalfa should be cut when about one-tenth of the heads are in blossom. If allowed to stand longer the hay is poorer and the succeeding cuttings are much decreased. It is usually cut three times in New York (Bulletin 221).

An Experiment Necessary. It is unwise to sow any large area of Alfalfa without first learning how to grow it. This first trial should include at least four plots for determining whether lime and inoculation are necessary. All the plots should be manured or else more plots should be added to test the effect of manure.

Suppose that a man uses lime and manure and fails, he knows nothing about whether he can grow Alfalfa or not. He might succeed if he applied soil inoculation. If he uses soil and manure and fails he does not know whether or not he would have succeeded if he had used lime.

Some man will say that he will apply lime, manure and inoculation on all the area to be sure to succeed, but this does not answer the question. Suppose he does this, he does not know but that he would have done as well if he had left off one or more of the treatments. When he comes to sow a larger area he will be applying unnecessary things at considerable expense.

On the College farm there are two soils on which we have grown Alfalfa successfully. One produces it abundantly without lime, manure and inoculation, the other on the same farm requires all these treatments for success. If any one of the three things is omitted the Alfalfa fails.

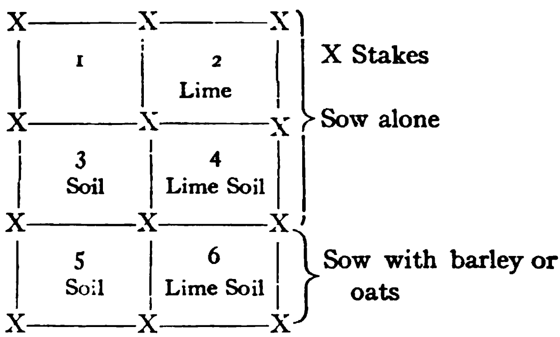
EXPERIMENT 101

The object of this experiment is to see if Alfalfa will grow on your farm and to learn the most profitable way of growing it.

Materials required, six-tenths of an acre of land, twelve stakes, six bushels of lime, fifteen pounds ($\frac{1}{4}$) bushel of Alfalfa seed, soil from an Alfalfa field or from a place where sweet clover grows.

Directions. Unless the land selected is very rich, manure should be applied to all the plots at the rate of about ten loads per acre or six loads for this area. Plow the land early in the spring.

Lay off a plot 8x12 rods and drive a stake every four rods as in the figure.



Apply six bushels of lime to plots 2, 4, 6. This is at the rate of twenty bushels or about 1500 pounds per acre.

Inoculate plots 3, 4, 5, 6 with soil from an Alfalfa field or from a place where sweet clover grows, using about one or two bushels.

Sow one-third of the Alfalfa seed on plots 5 and 6 with about seven quarts of barley or oats.

Continue to harrow the other plots until all weeds are subdued, then sow the Alfalfa alone, not later than August 1st.

The plots may of course, be of any size. The above areas are large enough to answer the questions. If one desires to plant a larger area the following year, he will know the best method to use and will have soil for inoculation purposes, if inoculation proves to be necessary on the farm.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

THE FOLLOWING BULLETINS ARE AVAILABLE FOR DISTRIBUTION TO THOSE RESIDENTS OF NEW YORK STATE WHO MAY DESIRE THEM AS LONG AS THE SUPPLY LASTS.

93 The Cigar-Case-Bearer.
121 Suggestions for Planting Shrubbery.
134 Strawberries under Glass.
135 Forage Crops.
136 Chrysanthemums.
137 Agricultural Extension Work, Sketch of its Origin and Progress.
139 Third Report upon Japanese Plums.
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164 Peach Leaf Curl.
165 Ropiness in Milk and Cream.
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170 Tent Caterpillars.
171 Concerning Patents on Gravity or Dilution Separators.
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246 A Gasoline-Heated Colony Brooder-House.
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249 Comparison of Four Methods of Feeding Early Hatched Pullets.
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Address, COLLEGE OF AGRICULTURE.
ITHACA, N. Y.

SUPPLEMENT TO

CORNELL

Reading-Course for Farmers

PUBLISHED MONTHLY BY THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY FROM NOVEMBER TO MARCH, AND ENTERED AT ITHACA AS SECOND-CLASS MATTER UNDER ACT OF CONGRESS JULY 18, 1894. L. H. BAILEY, DIRECTOR.

SERIES VIII. MISCELLANEOUS. | ITHACA, N. Y. FEBRUARY, 1908. | No. 39. ALFALFA.

DISCUSSION-PAPER ON FARMERS' READING-COURSE BULLETIN NO. 39

A Discussion-paper is sent out with all Farmers' Reading-Course Bulletins, for two reasons: (1) *We should like to have your own ideas on these subjects. On some of these points you have probably had experience that will be interesting and valuable to us. No matter what the Bulletin says, if you have different opinions on any of these subjects. do not hesitate to state them on this paper and give your reasons.* (2) *We should like you to use this paper on which to ask us questions. If there are any points which the Bulletin has not made clear or if there are any problems in your farming, whether on these subjects or others, on which you think we may be able to help you, write to us on this paper.*

THE NEXT READING-COURSE BULLETINS WILL BE SENT TO THOSE WHO RETURN TO US THIS DISCUSSION-PAPER, WHICH WILL BE AN ACKNOWLEDGMENT TO THE RECEIPT OF THE BULLETIN. *This paper will not be returned to you, but we shall look it over as carefully as we would a personal letter and write to you if there are any points about which correspondence is desirable. You may consider this Discussion-paper then, as a personal letter to us. It will be treated as such, and under no circumstances will your remarks be made public. As the Discussion-paper will contain written matter, it will require letter postage.*

If you are not interested in this Reading-Course Bulletin, we have others on other subjects, and we shall be glad to send any of these to you on request. The titles of the six Series of the Reading-Course Bulletins now available are: 1. THE SOIL AND THE PLANT. 2. STOCK FEEDING. 3. ORCHARDING. 4. POULTRY. 5. DAIRYING. 6. FARM BUILDINGS AND YARDS. 7. HELPS FOR READING. 8. MISCELLANEOUS. *Helps for Reading, in The Farmers' Wives' Reading-Course, on domestic subjects, is also sent to those who desire it.*

In order to secure more information about this plant in definite localities these questions arc asked. Your answers will be appreciated in giving the experience of both those who have been successful and those who have met failure.

Do you wish to try Alfalfa this year?

Will you conduct the experiments as outlined above, or will you merely sow Alfalfa without an experiment?

Are there any changes in the experiment that you will make?

Can you secure inoculated soil near your home, or will you need to have it sent?

Have you read Cornell Bulletins 221 and 237?

Names and addresses of persons in your neighborhood who have tried Alfalfa?

Questions for those who have tried Alfalfa and have failed.

Location of field, upland, bottom land, etc.

Kind of soil? Kind of subsoil?

Does the soil remain wet long? Does it "heave"?
Crop that preceded Alfalfa?
With what crop was Alfalfa seeded, or was it seeded alone?

Approximate date of seeding? Was lime used?

Was soil from an Alfalfa or sweet clover field used?

Was manure used?
How much injury was caused by weeds?
To what causes do you attribute failure?

Questions for those who have tried Alfalfa and have been successful.

Location of field, upland, bottom land, etc.

Kind of soil? Kind of subsoil?
Does the soil remain wet long? Does it "heave?"

Crop that preceded Alfalfa?
With what crop was Alfalfa seeded, or was it seeded alone?
Approximate date of seeding? Was lime used?
How much per acre?
If you tried with or without lime was there any difference in results?

Was soil from Alfalfa or sweet clover used for inoculation?

If you tried with and without inoculation was there any difference in results?
Are the tubercles or nodules present on the roots?

Was manure or fertilizer used?
Was it beneficial?
How much injury was caused by weeds?

How many acres of Alfalfa do you have?
Age of field?

What is the average yield per acre?
What is the average value per ton?

Other remarks

Name..................................

Date..................................

County................ Post office...........................

Note.—Your name appears on our mailing list as this Bulletin is addressed. If incorrect, please write us.

Address all correspondence to Farmers' Reading-Course, Ithaca, N. Y.

CORNELL

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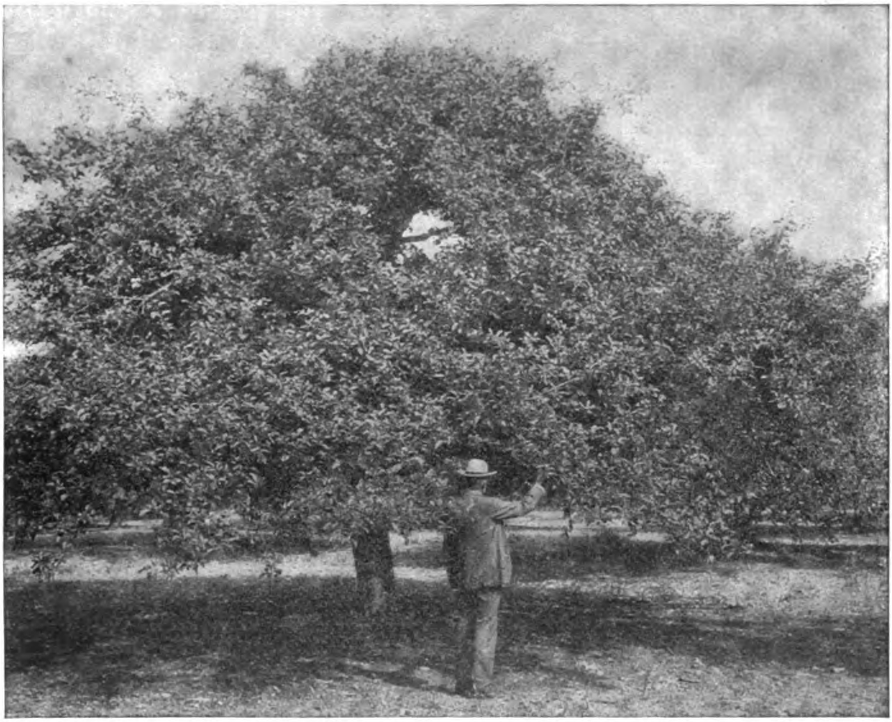
L. H. BAILEY, DIRECTOR. CHARLES H. TUCK, SUPERVISOR.

SERIES VIII. MISCELLANEOUS. | ITHACA, N. Y. MARCH, 1908. | No. 40. TILLAGE AND FERTILIZING IN ORCHARDS.



TILLAGE AND FERTILIZING.

C. S. WILSON.

So many methods of orchard management are practiced that the grower is often puzzled to know which is best. The purpose of this little leaflet is to compare these different methods, point out their advantages and disadvantages, and recommend a system which will be practicable for most orchards.

Results of Tillage.

Our orchards receive too little cultivation. The growers are making a serious mistake in not tilling their orchards more systematically. This fact has been brought prominently to our attention by the results of the orchard surveys which have just been completed in Wayne and Orleans counties. These surveys show unquestionably that cultivation is better than sod. The table below gives the five-year average yield and income per acre of all apple orchards in Orleans county under different methods of tillage.

	Bushels Per acre	Income Per acre
Tilled 10 years or more	327	$182
Tilled 5 years or more	274	138
Tilled over half of preceding 5 years	225	113
Sod over half of preceding 5 years	222	107
Sod 5 years or more	204	108
Sod 10 years or more	176	87

This table shows too great a difference in favor of cultivation. Other factors possibly may have influenced the yield and income. Undoubtedly the cultivated orchards received better spraying, pruning and fertilizing than the uncultivated. In order to eliminate these factors and compare tillage alone, another table is given. This compares only the orchards that are well cared for, but which differ in the matter of tillage alone.

	Bushels Per acre	Income Per acre
Tilled 10 years or more	337	$189
Tilled 5 years or more	296	148
Tilled over half of preceding 5 years	234	121
Sod over half of preceding 5 years	242	118
Sod 5 years or more	258	134
Sod 10 years or more	232	117

These figures show without a doubt the value and necessity of tillage. It should be remembered, however, that an orchard can be tilled too much. It needs a change, so to speak, now and then. Therefore,

instead of constant cultivation year after year, it is recommended to leave the ground in sod for one or two years in every five or six. This method combines tillage and sod, and gives excellent results.

Methods of Sod Culture.

In some orchards, however, cultivation would not be practicable. This is the case on a hillside where the ground is too steep to till. The grower would either pasture or mulch such an orchard.

(a) *Pasture.*— A comparison of the yields of sod orchards pastured differently give the following results:

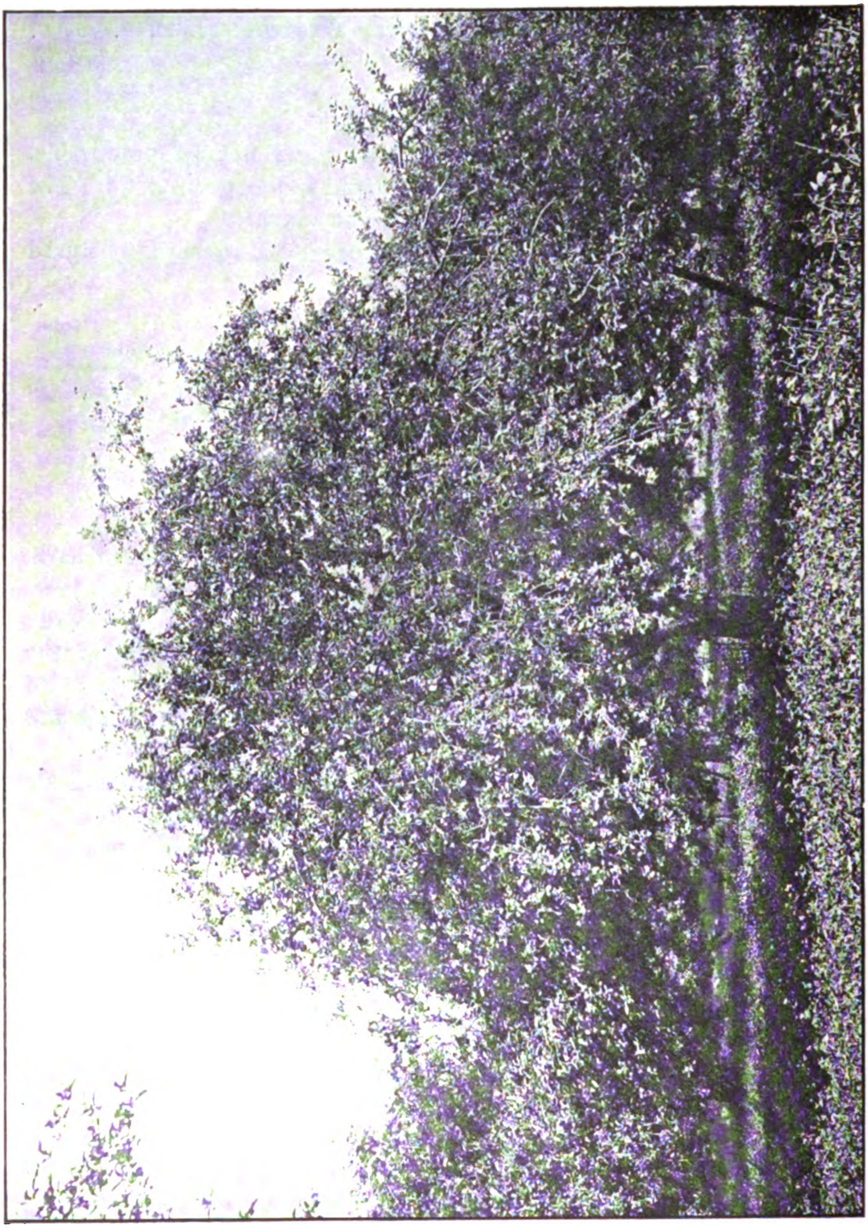
	Average yield in bu. Wayne Co.	Orleans Co.
Pastured with hogs.	271	312
Pastured with sheep.	216	208
Pastured with cattle.	159	153
Sod, not pastured.	185	217

The figures show that hogs are the best animals for the orchard. There are various reasons for this. In the first place, hogs do considerable rooting, and we may say that a hog-pastured orchard is practically a cultivated orchard. Moreover, hogs are fed mostly outside of the orchard, and the manure dropped is a constant addition to the plant food in the soil. Hogs also eat the wormy apples which drop early and thus a great many of the worms are destroyed,

Sheep are next to hogs. The manure dropped is a constant addition to the plant food. The sheep also keep the grass eaten closely, thus preventing excessive evaporation and loss of moisture which occur in the hay field.

Cattle and horses should never be allowed to run in the orchard. They are worse than nothing. They browse the branches as high as they can reach, and ofter break and bark the larger limbs.

(b) *Mulch.*—Mulching consists in cutting the grass and allowing it to decay as it falls, or throwing it around the trees. Do not practice the latter. If the grass is cut, is should be allowed to lie as it falls. There is considerable discussion at the present time regarding the beneficial results of mulching. In case it is impossible to cultivate an orchard, probably the next best treatment is to pasture it with hogs or keep it mulched. Do not, however, practice mulching where cultivation is practicable and possible.



By Courtesy of Cornell Countryman.

Method of Tillage.

Cultivation should begin as early as possible in the spring. Plow the orchard shallow, turning the furrows towards the rows. Cut the sod, if necessary, with a disk, and then harrow with the spring tooth. Cultivate thoroughly about every two weeks with a spring tooth, or other suitable implement, until the first of July. Be careful to cultivate close to the trees, and yet never allow the implement to bark them. If necessary use a grub hoe to dig close to the base of the trunk. *Do not cultivate after July* 1st. Late cultivation induces late growth of the trees and does not allow the wood to mature early. In the case of the tree fruits, early maturity is desirable, because the color of the fruit depends on the ripening. The ripening of the fruit depends on the ripening of the wood. Therefore we should seek to ripen up the wood in the orchard as early in the summer as possible; this is the reason for stopping early.

About the middle or latter part of July plant some cover crop which at the time of harvesting will have made sufficient growth to form a compact mat on the ground. Never allow an orchard to pass the winter without a cover of some kind. If the soil has no covering in the fall, a little rain makes the ground so muddy that it is almost impossible to work in the orchard. Moreover, it makes the apples dirty to fall on the bare ground. Not only does a cover crop protect the soil and trees during the winter, but it also forms a convenient mat which makes the orchard operations much easier and more agreeable. Good cover crops are mentioned below.

Fertilization.

The orchards which are well tilled require less fertilizing than the untilled ones, since cultivation renders the plant food in the soil available. Every orchard, however, requires some fertilizing, either in the form of barnyard manure, commercial fertilizer, or by means of cover crops. A two-year average yield of the fertilized apple orchards in Wayne county gives fifty-five bushels more per acre than the unfertilized.

Barnyard manure.—Barnyard manure is the best all-round fertilizer for the orchard. Usually orchards receive too little of it. It is possible, however, since it is rich in nitrogen which produces vigorous wood growth, to apply it too often and in too great quantities. The best results are obtained when it is used alternately with commercial fertilizers. Often barnyard manure is applied one year, and a commercial

fertilizer the following. About five to ten tons per acre is a good dressing. The most convenient time for applying it is in the spring before growth starts and while the ground is still hard enough to drive on. Spread it evenly over the entire surface. Do not heap it beneath the trees.

Commercial fertilizer.—A fertilizer rich in potash and phosphoric acid is desirable for the orchard. Nitrogen is also a necessary element, but for orchard work is less important than potash. Moreover, if sufficient barnyard manure is applied and cover crops are grown, the nitrogen will be furnished in sufficient quantities through these agencies.

That potash is an important element of fertilizer, is shown from the fact that it constitutes a large proportion of the ash of the wood of a fruit tree and more than fifty per cent of the ash of the fruit, besides forming the base of the well-known fruit acids. At the present time muriate of potash is the best form in which to secure a supply. About two hundred pounds per acre is a good dressing. Another good source of potash for orchard work is wood ashes, providing it has not been weakened by leaching. Often, however, the hard wood ashes which are bought on the market contain only about one-half as much potash as they should.

Phosphoric acid is obtained in the form of high grade superphosphate and the bone compound. It is probably less important in fruit plantations than potash, although this order is reversed in general farming. Two hundred pounds of ground bone and one hundred pounds of South Carolina rock superphosphate in connection with the muriate of potash, as recommended above, form a good commercial fertilizer for the orchard.

Cover crops.—The cover crop is not only a fertilizer, but it also provides a mulch, and when plowed under the following spring improves the physical condition of the land by adding humus. The kinds of cover crops best suited for orchard work are mammoth clover, vetch and crimson clover of the leguminous plants, and buckwheat, rye and oats of the non-leguminous.

A Five-Year Plan of Orchard Management.

In order to combine the subject of fertilization and tillage and also to simplify the problem of the grower, the following five-year plan of

orchard management is recommended. This plan is adapted to the apple on soils ranging from sandy loam to clay, and on land which can be cultivated. It assumes that the land has been in sod for a year with previous cultivation, or that the sod can be plowed without injury to the roots.

First spring.—Plow the ground shallow, cut the sod with a disk, and follow the disk with a spring-toothed harrow until the soil is in good condition of tilth. Keep all weeds down and the soil well cultivated at intervals of about two weeks until July 1st. About the middle of July sow hairy vetch at the rate of one bushel, or crimson clover at the rate of eight quarts per acre.

Second spring.—Spread five tons per acre of barnyard manure evenly over the whole orchard. Plow the ground in the spring and keep cultivated until the first of July as above. About the middle of July plant mammoth clover and oats, one bushel of oats and six quarts of clover per acre. The oats will grow faster and form a protection to the clover.

Third spring.—Spread broadcast a chemical fertilizer of the following proportions:

South Carolina rock superphosphates................	100 lbs.
Ground bone..................................	200 "
Muriate of potash..............................	200 "

Leave the ground in sod during the summer. Cut the clover twice, allowing it to lie as it falls.

Fourth spring.—Apply barnyard manure again evenly at the rate of five tons per acre. Leave the orchard in sod during the summer and pasture with hogs or sheep.

Fifth spring.—Plow early and shallow. Cultivate thoroughly as before, until July 1st. After plowing, harrow in the commercial fertilizer of the same proportions and amounts as recommended above. About July 15th sow a cover crop of rye, about two bushels per acre. Mix a little buckwheat with the rye. The buckwheat grows more rapidly and acts as a protection for the rye.

Once during the five years add about twenty-five bushels of lime per acre. Ground lime of commercial grade, or slaked stone lime may be used.

CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

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SERIES VIII. MISCELLANEOUS.

ITHACA, N. Y. MARCH 1908.

No. 40. TILLAGE AND FERTILIZING IN OCHARDS.

DISCUSSION-PAPER ON FARMERS' READING-COURSE BULLETIN NO. 40

A Discussion-paper is sent out with all Farmers' Reading-Course Bulletins, for two reasons: (1) *We should like to have your own ideas on these subjects. On some of these points you have probably had experience that will be interesting and valuable to us. No matter what the Bulletin says, if you have different opinions on any of these subjects, do not hesitate to state them on this paper and give your reasons.* (2) *We should like you to use this paper on which to ask us questions. If there are any points which the Bulletin has not made clear or if there are any problems in your farming, whether on these subjects or others, on which you think we may be able to help you, write to us on this paper.*

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Too many orchards are unprofitable because they are not properly tilled and fertilized. This bulletin points out practical methods to be employed in making such orchards more profitable.

1. Do you know of any well managed orchards where tillage vs. sod has been tried?

2. Do you prefer sod culture by means of pasturing or mulching?

3. Why is late cultivation injurious?

4. What fertilizer or combination of fertilizers would you advise?

5. Are cover crops found in general practice throughout your neighborhood?

6. What is the value of a general plan of orchard management?

7. What in your opinion is the best plan?

Name....................................

Date....................................

County.................... Post office........................

Note.—Your name appears on our mailing list as this **Bulletin** *is addressed. If incorrect, please write us.*

Address all correspondence to Farmers' Reading-Course, Ithaca, N. Y.

CORNELL

Reading-Course for Farmers' Wives

PUBLISHED MONTHLY BY THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY, FROM NOVEMBER TO MARCH, AND ENTERED AT ITHACA AS SECOND-CLASS MATTER UNDER ACT OF CONGRESS, JULY 16, 1894. L. H. BAILEY, DIRECTOR.

MARTHA VAN RENSSELAER, *Supervisor.*

SERIES VI. ITHACA, N. Y., NOVEMBER, 1907 No. 26.

Dear Reader:

We are entering on the sixth year of the Farmers' Wives Reading-Course. At frequent intervals our lists have to be revised. If you desire the bulletins continued to your address will you WRITE AT ONCE. **Otherwise your name will be dropped from the list.** *We shall be glad to know of your continued interest.*

With a limited appropriation for the work of the Reading-Course, it is desired to make every expenditure and every effort count for the good of our members. We shall therefore appreciate a communication from you stating the value to you of the bulletins and suggestions for their improvement.

For purposes of the revision of the mailing lists, a postal card containing name and address is sufficient, but we prefer to have you take the time to fill out the accompanying sheet.

Very sincerely,

MARTHA VAN RENSSELAER,

Supervisor Farmers' Wives' Reading-Course.

You are enrolled as a member of the FARMERS' WIVE. READING-COURSE. Do you wish the Bulletins continued? If so, please fill out this blank and return.

Name ....

Post Office ....

1. Have you suggestions to make concerning the subject matter of the bulletins or the work in general?

2. Has the reading thus far been a benefit to you?

3. Is it too difficult in the main or is it too elementary?

4. Has it stimulated an interest in further study?

5. What part of the course thus far has interested you most?

NOTE.—If more space is needed for answering these questions use a separate sheet.

NEW YORK STATE COLLEGE OF AGRICULTURE, CORNELL UNIVERSITY.

Announcement of Courses of Instruction in Home Economics.

Beginning in the fall of 1907, Home Economics is established as a regular department in the College of Agriculture. The object of this department is to provide courses of instruction in those branches which best serve the interests of women students and to furnish a basis for the practical correlation of Chemistry, and the Physical, Biological and Social Sciences with Home Economics. Laboratory facilities are being provided, together with other modern equipment. The work in Home Economics is in charge of Miss Flora Rose, and Miss Martha Van Rensselær.

The courses to be given in this Department are devised to meet the needs of three classes of students (days and hours of the exercises left for special arrangements):

1. Regular academic work is planned for those students desiring special training in Home Economics.
2. Classes will be open to other students who desire only a general knowledge of the principles and practice of Home Economics.
3. A winter-course requiring less previous preparation on the part of the student, is open to those desiring brief practical training in Home Economics. No university credit is given for this course.

Description of Academic Courses.

The Academic work embraces seven classes as follows:

1. The Home;
2. House Construction, Sanitation and Decoration;
3. Household Management.
4. Foods, Elementary Course.
5. Foods, Advanced Course.
6. Special Problems. For teachers.
7. General Course. For students not desiring special training in Home Economics.

University Extension in Home Economics.

The extension teaching in Home Economics is in two lines,— the winter-course and the reading-course.

Winter-Course.

The College of Agriculture offers for the third year a course in Home Economics, the object of which is to furnish such instruction as will improve the farm homes of the state. Special attention will be given, so far as the facilities permit, to instruction in sanitation, foods, home decoration, and household management, together with the relation of homemakers to the social forces of the community. The instruction is suited to both men and women so far as both are interested in building and maintaining a home.

The course is especially adapted to those who would find it possible to accompany members of the family who come to attend the other Winter-Courses. There is no age limit above seventeen years in this course. It is an excellent opportunity for women who have had household experience and who would supplement it with

scientific knowledge. Laboratory work is provided. The instruction is given by Miss Van Rensselær and Miss Rose, with the help of other members of the staff.

The expense is that of travel and living. There is a laboratory deposit fee of $5.00, to cover cost of breakage and materials used. Any unexpended balance is returned to the student. Assistance will be gladly given to those who wish to make arrangements while in Ithaca for inexpensive living.

Reading-Course for Farmers' Wives.

For several years there has been provided a Reading-Course for Farmers' Wives which consists of bulletins on home topics. These are sent as desired in the State of New York according to the following series:

Series I. *Farmhouse and Garden.* (1) Saving Steps; (2) Decoration in the Farm Home; (3) Practical Housekeeping; (4) The Kitchen-Garden; (5) The Flower-Garden.

Series II. *The Farm Family.* (6) The Rural School and the Farm Home; (7) Boys and Girls on the Farm; (8) Reading in the Farm Home; (9) Home Industries; (10) Household and Garden Pests.

Series III. *Sanitation and Food.* (11) Home Sanitation; (12) Germ Life; (13) Human Nutrition; (14) Food for the Farm Family; (15) Saving Strength.

Series IV. *The Farm Table.* (17) Flour and Bread; (18) Dust as related to Food; (19) The Selection of Food; (20) Canning and Preserving.

Series V. *Suggestions on Farmers' Reading Course Bulletins.* (21) to (25) Programs for Evenings with Farmers' Wives' Clubs (16).

The reading-courses are without cost to residents of the state. The course is not intended to be a full correspondence course with books as a basis of the work. However, books will be recommended that are considered to be good for special courses of reading, either to individual readers or to reading clubs.

Readers will find much advantage in forming themselves into clubs. Six to a dozen persons are usually sufficient for an energetic and effective club. The above bulletins are issued monthly. Usually it requires two meetings, or discussions, to derive the most benefit from a bulletin. Therefore, it is well to have the club meet at least twice a month. The club meeting may be a very pleasant, social feature, particularly if held at the residences of the members.

If you are interested in forming a club, send for Bulletin No. 16, which gives instructions for organizing and suggested programs.

CORNELL

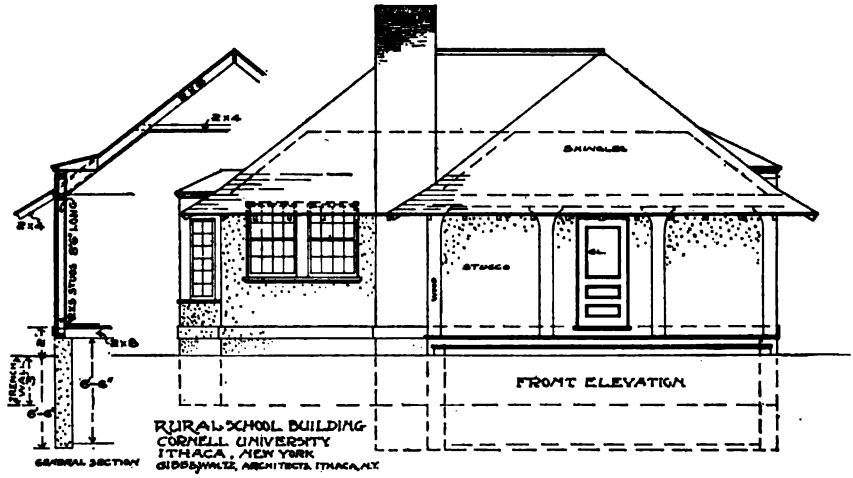
Reading-Course for Farmers' Wives

Published Monthly by the New York State College of Agriculture at Cornell University from November to March, and Entered at Ithaca as Second-class Matter under Act of Congress July 16, 1894.
L. H. Bailey, Director.

Martha Van Rensselaer, *Supervisor.*

SERIES VI. ITHACA, N. Y., JANUARY, 1908 **No. 27.**

A MONTH OF EDUCATION DISCUSSION.



The Cornell Rural School House.

The New York State College of Agriculture at Cornell University has erected a small rural school house on its grounds, to serve as a suggestion in school house architecture and to contain a rural school as a part of its nature-study department. In response to many inquiries, this leaflet is issued, containing brief description.

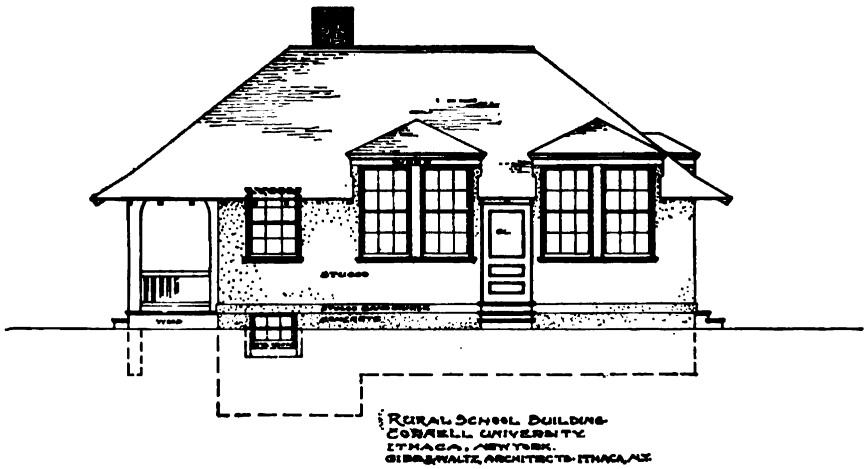
The prevailing rural school house is a building in which pupils sit to study books. It ought to be a room in which pupils do personal work with both hands and mind. The essential feature of this new school house, therefore, is a work-room. This room occupies one-third of the floor space. Perhaps it would be better if it occupied two-thirds of the floor space. If the building is large enough, however, the two kinds of work could change places in this school house.

It has been the purpose to make the main part of the building about the size of the average rural school house, and then to add the work-room as a wing or projection. Such a room could be added to existing school

buildings; or, in districts in which the building is now too large, one part of the room could be partitioned off as a work-room.

It is the purpose, also, to make this building artistic, attractive and homelike to children, sanitary, comfortable, and durable. The cement-plaster exterior is handsomer and warmer than wood, and on expanded metal lath it is durable. The interior of this building is very attractive.

The pictures show the building just as completed, before the grading of the grounds. School-gardens and play--grounds are being made at one side.



NORTH ELEVATION

The cost has been as follows:

Contract price for buildings complete, including heater in cellar, blackboards, and two outhouses with metal drawers........	$1800 00
Tinting of walls..	25 00
Curtains...	16 56
Furniture and supplies..................................	141 75
	$1983 31

In rural districts, the construction might be completed at less cost. The average valuation of rural school buildings and sites in New York State in 1905 was $1,833.63.

The building is designed for twenty-five pupils in the main room. The folding doors and windows in the partition enable one teacher to manage both rooms.

Construction Details.

In working out the problem it has been the aim to accomplish a maximum of accommodation combined with an artistic appearance and a minimum of cost. The materials used are such as may be readily obtained and easily handled.

The building is placed on a concrete foundation composed of gravel or broken stone, cement, and sand in the proportion of one part cement, three parts sand, and five parts gravel.

The foundations under the school-room proper are carried down below frost only, while under the vestibule the walls are of sufficient depth to form a small cellar for the heating apparatus.

The superstructure is of ordinary frame construction as follows:

Joists	2″ x 8″, 16′ on centers;
Studs for inside walls..........	2″ x 5″, 12′ on centers;
Studs for outside walls...........	2″ x 5″, 12′ on centers;
Rafters	2″ x 6″, 16′ on centers;
Hips and valleys...............	2″ x 8″.

The entire exterior walls are stuccoed with cement mortar, rough-cast on metal lath nailed directly on the studding, the stucco being returned in all openings, thus doing away with outside casings wherever possible. The roof is shingled over sheathing laid open in the usual way, and is designed (as shown in sketches) with low and broadly projecting eaves with the windows cutting up through them.

The interior is plastered on plaster-board with patent plaster, two-coat work trowelled smooth and decorated in simple gray green for side walls and pale yellow for ceilings. The floors are of ⅞″ matched pine, and the standing trim is yellow pine finished natural. This trim has been used as sparingly as possible and is not moulded. Wherever possible, door and window casings have been omitted, the plastering returning into jambs with all corners rounded.

All doors are stock pine. Inside doors 1⅜″ thick. All sash is 1⅜″ glazed with good quality double thick glass.

The openings between school-room and work-room are fitted with glazed swing sash and folding doors, so that the rooms may be used either singly or together, as desired.

The work-room has a bay-window facing south and fitted with shelves for plants. Slate blackboards of standard school heights fill the spaces about the rooms between doors and windows. The building is heated by hot air; vent flues of adequate sizes are also provided so that the rooms are thoroughly heated and ventilated.

On the front of the building and adding materially to its picturesque appearance, is a roomy veranda with simple square posts, from which

entrance is made directly into the combined vestibule and coat-room and from this again by two doors into the school-room.

Education for the boys and girls in rural districts.

The State has prodived liberally for furnishing agricultural instruction to the sons and daughters of farmers. Already a large number of them are attending the winter-courses in the College of Agriculture and the

The Cornell rural schoolhouse from the school garden.

longer special and four-year courses. Gradually the state has been building up a class of educated, progressive farmers whose influence is felt in dignifying agriculture and making it more profitable in the state. They make a happier and more contented class of men and women in farming than are found when the education of the farmer boy and girl ended with the rural school and the surroundings of the farm home. There is still much more good material in the counties of the state, and the farms need the effort of skilled and intelligent workers.

Does the rural school education satisfy your ambitions for the boy and the girl in your home?— Can you make them happy and contented to remain on the farm where their help is so much needed, if there is not offered in this day of progress a larger outlook and a better acquaintance with improved methods in farming? The New York State College of Agriculture offers a winter-course, lasting three months in

1. General Agriculture
2. Horticulture
3. Dairy
4. Poultry
5. Home Economics

These, with the longer courses are free of tuition, and their advantages are extended to the men and women interested in better farming and better farm homes. Any one interested may send for announcements of these courses.

The rural school should supply the preparation and incentive.— Not all of the children attending the rural school will remain on the farm. They may be better fitted for other callings. The large number who do remain should have instruction in practical matters related to their every day living. If they are taught to find the cubical contents of a body, it is not good teaching unless the prospective farmer applies the knowledge to his oat-bin and learns how large a bin is required to store fifty bushels of oats; or instruction in denominate numbers should teach a boy or girl how much material is needed to paper, carpet or plaster a room. It is as important to teach children how the corn grows, of what milk is composed, what the weather signs mean, the structure of the egg, or the right conditions of the soil for a good crop as to teach much of the unused knowledge which habit, not usefulness, has made a part of the rural school program. It is better that children come from the schools able to keep the farm and household accounts in a businesslike way, which is one means of making the farm profitable; better that girls learn in their lessons in drawing what colors to choose for the decoration of their walls; better to have a knowledge of the life history of the fly and mosquito with means of getting rid of them or to acquire a knowledge of wayside weeds and their practical value in the household. In short, there is a fund of practical topics which will make the school intensely interesting and alive.

Young men and women going from the rural school to the college should not be handicapped by scanty preparation in English, practice in taking notes on lectures and the ability to express themselves easily. Experience proves agricultural students to be earnest and capable, winning the respect of their fellow students. Let the rural schools prepare them for standing shoulder to shoulder with those educated in larger

schools and outstripping them if they can. This means a larger pride in the rural school, greater care to secure practical teachers, more expenditure of money for healthful conditions and better supervision to make the rural school correlate its work with the high school and college. The boys and girls are worth it and the stimulus for growth and advancement must be placed in the rural school or else the country boys and girls will have less chance in life than their city and village friends.

The rural school may inspire in its girls a desire for success in home life, for to make an ideal farm home is a worthy ambition. With its varied demands for intelligent labor, as varied and as important as work on the farm, there is need of education for girls which shall properly fit them for their field usefulness. Women are realizing their need of special training and are taking advantage of the Winter-Course in Home Economics. Among them will be some who will wish to take the longer four-year course. Young women from the farms have good material for preparation in Home Economics not only for practical application to home life but as teachers. The State now offers instruction to its women in Home Economics. It is hoped that the rural schools may foster in its girls a desire for this training, and start them in their preparation. Announcements for these courses may be had by writing to the College of Agriculture.

Subjects for Clubs to Discuss.

The suggestions regarding the rural school are sent to our readers because there is more enthusiasm than formerly on the question of securing better supervision in these schools, better sanitary and aesthetic surroundings, both in the school house and out, and more practical teaching of subjects that boys and girls will use in after life. This bulletin is issued at this time with the hope that those receiving it will give special attention to the conditions existing in their rural school districts. A more comprehensive bulletin was issued in November 1903, a copy of which will be sent you if you do not already possess it.

ADVANCED READING FOR FARMERS' WIVES.

It is impossible to continue publishing bulletins indefinitely for the FARMERS' WIVES' READING-COURSE. It is believed that after the four years' course has been taken, more extensive reading and study are needed. For this purpose we suggest the reading of books, on which our members may report to us their progress and opinions. In connection with these books there will arise, as in connection with the bulletins, questions of interest in home life which we shall be glad to answer or we will refer the reader to sources of information. If readers are not in

possession of the books necessary for winter's work, it is suggested that they avail themselves of the State Traveling Libraries, Department of Education, Albany, N. Y. Under the rules of this library, books may be obtained for three months at the nominal price of $1.00 for ten copies and 50 cents in addition if books are to be retained for six months. A fee of $2.00 is required for 25 volumes. The fee in all cases entitles borrowers to free transportation by freight both ways. The club sending for these books pays local cartage.

Following is a list of books suggested for home and club study. For purposes of general information books are mentioned which will be in the line of culture. Other books are added for special study in farm or household topics.

Required Books for 1907 and 1908 are:

The House, Isabelle Bevier.

Household Management, Bertha M. Terrell.

Household Bacteriology, S. Maria Elliott.

Questions to be answered are found in the books.

These books may be purchased from the American School of Home Economics, Chicago, or they will be included in the list to be secured free of charge as a traveling library from the Department of Education, Albany.

In addition to the above it is suggested that books on general subjects be included in the traveling library and others on farm subjects for men interested in them; also some for the children in the home. The list given in this bulletin provides for these conditions.

Books of interest on farm topics are:

Fertility of the Land, I. P. Roberts.
Soil, F. H. King.
Farmstead, I. P. Roberts.
Feeds and Feeding, W. A. Henry.
Experiments with Plants (for Teachers), W. J. V. Osterhout.
Milk and Its Products, H. H. Wing.
Modern Silage Methods, F. W. Woll.
Principles and Practice of Butter-Making—McKay and Larsen.
Poultry Craft—Robinson.
Fertilizers—E. B. Voorhees.
Forage Crops—E. B. Voorhees.

List of books for children. In addition to the following, try to interest the children in books on poultry, birds, plants, etc.:

1. Æsop's Fables.
2. Bullfinch—Age of Fable.
3. Scott—Kenilworth or Ivanhoe.
4. Lanier—Boy's King Arthur.
5. Twain—Tom Sawyer.
6. Kingsley—Westward Ho!
7. Kipling—The Jungle Books.
8. Thompson-Seton—Wild Animals I have known.
9. Hughes—Tom Brown's School Days.

10. Louise M. Alcott—Little Men. Little Women.
11. Stevenson—Kidnapped. —Treasure Island.
12. Shaler—Story of our Continent.
13. Stuart Edward White—The Blazed Trail. In Silent Places.
14. Ernest Thompson-Seton—Life of Animals.
15. Blanchen—Birds and Nature.

List of books on general subjects from which to choose:

History of the United States, John Fiske.
Life of William Morris.
Memoirs and Letters of Robert Louise Stevenson.
Essays—Hamilton Mabie.
Abraham Lincoln, Ida Tarbell.

Fiction.

Lorna Doone—Blackmore.
The Virginian—Owen Wister.
Les Miserables—Victor Hugo.
Ben Hur—Lew Wallace.
Man Without a Country—Edward Everett Hale.
Jane Eyre—Charlotte Bronte.
Little Shepherd of Kingdom Come—Fox.
The Right of Way—Parker.
The Reign of Law—Allen.
Ramona—Helen Hunt Jackson.
The Otherwise Man—Van Dyke.
Hugh Wynne—Mitchell.
The Weldings—LaFayette. McLaws.
Huckleberry Finn—Mark Twain.
Main Traveled Roads—Garland.
Being a Boy—Warner.
Choose also works from Scott, Dickens, Thackeray and Elliott.

Poetry.

The complete works of any standard poets may be selected as Tennyson, Shelly, Scott, Moore, Longfellow, Whittier, Bryant, Lowell, Riley's poems, also Stevenson's and Eugene Field's poems of childhood are of great interest.

FARMERS' WEEK AT CORNELL.

On February 17–22, 1908, "Farmers' Week" is to be held at the New York State College of Agriculture.

The Poultry Institute and Show is held February 18, 19 and 20. The Experimenter's League meets in Farmers' Week.

All the work of the College is open to visitors with lectures and demonstration for the benefit of visitors. Special programs will be held for women. It is desired that women will come on this occasion and receive the benefits to be derived for the farm home.

The Department of Home Economics will furnish lectures and demonstrations to visiting farm women.

CORNELL
Reading-Course for Farmers' Wives

PUBLISHED MONTHLY BY THE NEW YORK STATE COLLEGE OF AGRICULTURE AT CORNELL UNIVERSITY FROM NOVEMBER TO MARCH, AND ENTERED AT ITHACA AS SECOND-CLASS MATTER UNDER ACT OF CONGRESS JULY 16, 1894. L. H. BAILEY, DIRECTOR.

MARTHA VAN RENSSELAER, *Supervisor.*

SERIES VI. ITHACA, N. Y., MARCH, 1908 No. 28

ANOTHER STUDY ON HOUSEHOLD EQUIPMENT.

The manufacturer equips his factory in such a way as to save the time and strength of his workmen. It is a good financial investment to do this. So it is in the household for every hour of a woman's time spent advantageously is a clear financial gain.

If a bread mixer makes better bread and simplifies the labor, the housekeeper is a true economist to buy it. I find in my visits among the farmers' wives that the bread mixer and washing machine are generally accepted as good labor-saving devices. The bread mixer seen in the illustration is the one most usually found. I shall be glad to know the experience of our readers in regard to its use.

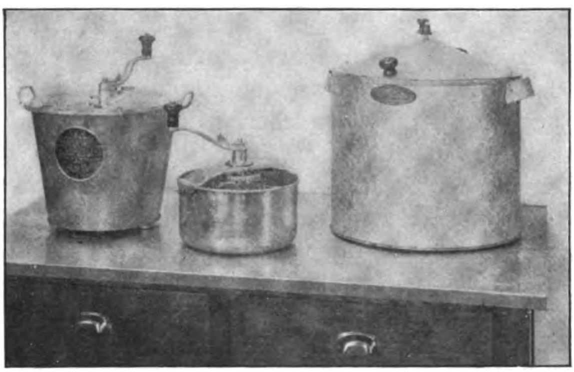


FIG. 1.—*Bread mixer, cake mixer, dish-washer.*

A dish-washer is seen at the right in the illustration. This consists of the galvanized iron bucket and, fitting into it on a pivot, a receptacle for dishes, which, after the cover is placed, is revolved in hot, soapy water by means of a crank at the top. The receptacle containing the dishes is lifted out and hot water poured over them. They may then be drained in the sink or on top of the dish-water, the tray resting on the inverted cover where they dry without wiping. There are certainly advantages in the use of a dish-washer as it saves time, even though the dishes have to be placed singly. The turning of the crank is exceedingly easy. A disadvantage yet to be overcome is the means of emptying the pan, as the water has either to be dipped out or the pan lifted to empty it or

it may be siphoned out. Then, if the dishes are quite greasy, the grease stands on the dishes as they are lifted out. This may be remedied by using boiling hot water, washing in a new water or rinsing more thoroughly in the sink. If you have solved the problem of dish-washing in the house we should like to hear from you.

As far as possible, castors should be placed on tables and on other kitchen furniture to secure easy moving. Have you not had difficulty in moving the flour barrel every time you wanted to clean the floor? Ask the "handy man about the house" to place the barrel on a strong frame with a castor at each corner. Then the barrel is moved easily for cleaning or for other purposes. It is a common sight, when the flour is low, to see a woman with head and arms reaching into the barrel trying to get a quantity of flour. This may be obviated by having the barrel hung on a pivot so that it may be easily tipped and supported.

A small zinc-covered kitchen table having strong castors, can be moved from place to place in the kitchen, and is a great convenience. I think you will not be without it after once trying it. The zinc is kept clean very easily and wears much better than table oil-cloth.

Without undertaking to decide upon the best washing machine, it is certain that a good one should be added to the household stock of conveniences. There may be man or boy power at the crank, or for about $17 a machine may be purchased to run by water power. This is better than the more laborious means of turning a crank. It is more expensive but with a scarcity of help shall we not expend more money in saving effort? On the farms where power is employed for threshing, cutting wood, churning and separating, may it not be used for washing? A small steam laundry plant, owned by several families and properly managed, may be made materially to reduce the labor in the household. An objection, is perhaps the expense of the equipment and the trouble of running it. The same difficulties have been overcome in the use of power for threshing the oats or separating the cream. A good subject for club discussion is a sanitary and economic way of doing the family wash. It is possible the power at the cheese factory might be utilized to run the laundry and the delivery of clothes may easily be effected by the same means as that used for carrying the milk.

The kitchen fire has seen a series of improvements since the time of the great chimneys in the back in which hung the "lug pole" of green wood from which were suspended the pothooks and kettles, often the precious possessions of the family.

In strong contrast to the utensils of various sizes, shapes and materials now covering a stove, were the heavy iron or brass kettles few in number which hung above the crackling fire. Here the vegetables were often

boiled in one pot and the chimney place was so large that an entire beef might be roasted at one time.

> "A fireplace filled the room one side
> With half a cord of wood in —
> There warn't no stoves (tell comfort died)
> To bake ye to a puddin."—*Lowell.*

There was a time in the colonies when the stove was set in the outside wall of a house with the door opening out of doors. The housekeeper went outside to put wood in the stove. Finally the coal and gas ranges and the electric cookers have improved conditions for cooking. The principle of cooking is ever the same, to continue to furnish fuel to supply the wasted heat. This requires constant watching and is an expensive part of housekeeping as well as one to take the time and strength of the housekeeper.

In the German army for some years the "Hay Box" has been used to advantage and it is recommended to housewives as a means of saving fuel and securing good results in cooking cereals, chicken, macaroni, or anything requiring long, slow cooking or steaming.

The cooker may be only a close, wooden box with good cover lined with hay, excelsior, asbestos, cork or other non-conducting material. The principle is to retain the heat which is generated by use of any ordinary coal, gas or oil fire. Nests should be made in the hay in which will fit closely the pots containing the articles to be cooked. The food is to be brought to the boiling point in utensils which must be very closely covered and placed in the nests prepared in the hay or other non-conducting material with which the box is lined. The box must be closed immediately in order to conserve the heat. The outside cool air cannot reach the utensils nor the inside hot air escape. The food continues to cook evenly and thoroughly. About twice as much time is required as in cooking over the flame. There is little evaporation. Care must be taken to cover the food with water as it is needed to hold the heat.

FIG. 2. "*The Hay Box.*"

Many articles of food are better for long, slow cooking

and as neither fire nor attention is needed, it proves an economical means of preparing food for the table.

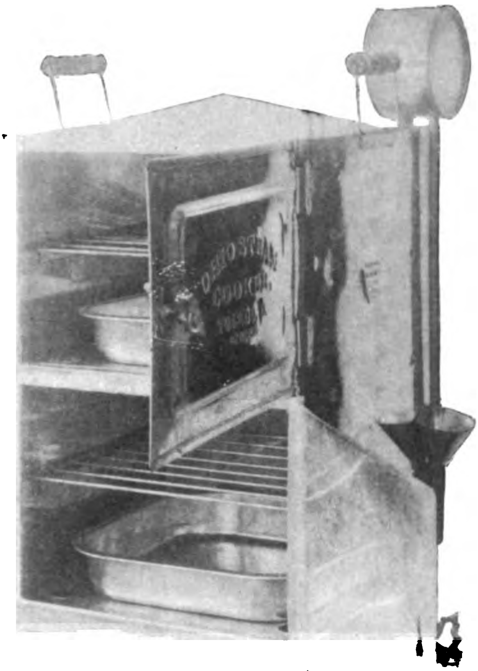


FIG. 3. *A steam cooker.*

While very desirable cookers are on the market, many make their own so called " hay boxes."

The expense is in the cost of the box, the packing and utensils. The chief difficulty in a home-made fireless cooker is in getting utensils without handles and which have very close fitting covers.

One cooker on the market is made of fiber which is easily kept clean and which acts as a non-conductor of heat. The expense of

this one is not far from $4.00. Another is made of non-absorbent washable metal. Both of these stand upright and receive the utensils with food thoroughly heated through, one utensil being placed upon the other. The latter has a seamless, deep cover, and the inner receptacle is made of rustless metal. These are in different sizes, ranging in price from $6.50 to $13.50.

The time required for cooking is a matter of experiment for one who has not used a fireless stove although those on the market have furnished with them time tables and recipes. I have prepared in the cooker many a meal consisting of chicken or potroast, potatoes and another vegetable. These were put into the cooker, the chicken several hours, the vegetables two hours, before serving. After they had first been boiled on the stove, the chicken a half hour, the potatoes and onions, squash, turnips or cauliflower ten minutes, they are placed each in a different compartment in the fireless stove until ready to serve. The kitchen bears no evidence of the preparation for dinner except in the other articles to be served, until about ten minutes before meal time, when the cooker is opened to take out the food. Cereals may be cooked for a short time the night before on the stove, placed inside the box and be found hot and thoroughly cooked in the morning.

FIG. 4. *A good way to wring the mop.*

Most women who use a steam cooker regard it as a valuable asset. If desired to use one flame or opening over the fire for several articles, a cooker like the one shown in Fig. 3 makes it quite possible. It is no uncommon practice to cook chicken, potatoes, onions and custard at one time in one of these steamers and some of them are so arranged as to whistle when the water in the lower part is out.

Most people dread the task of mopping. The wielding of the mop over the floor is not the difficult part. Putting the hands into the dirty water and wringing the mop may be a good wrist exercise, but neither pleasant nor very easy. For $1.75 a mop-wringer may be had which operates by pressure on a handle as seen in Fig. 4. It just

happens that the photographer caught a man operating it, but it is not too difficult for a woman to manage.

How frequently do we waste time and energy in looking through various cans containing soda, spices, etc. for the article we need quickly. Perhaps the labels we pasted on have come off. An arrangement as seen in Fig. 5 shows at a glance just where to find the cinnamon, rice or red pepper. The difficulty is in getting bottles with close fitting stoppers, and in the expense of the bottle. It may be well to consult the druggist regarding good bottles for this purpose.

FIG. 5. *Glass bottles or Mason jars save needless hunting.*

I have found a mangle for the household ironing to be a paying investment. These may be had costing from $15.00 to $40.00 and run by gasoline, gas, electricity or some are made to iron simply by the pressure brought to bear on the rollers. Only flat clothes are run through the mangle, but the time taken for their ironing is so much less than that required by the usual method that the mangle is paid for in a comparatively short time. Unless the fire is kept up for other purposes, there is also a saving of fuel.

Many who are situated where they can use gas or electricity are buying the flat-irons which are heated by these means. A new iron is on the market which is run by the burning of denatured alcohol and there are also irons heated by charcoal. The value of these irons is mainly in saving the heat and the travel from the ironing-board to stove.

COOKING MADE EASY.

I took dinner recently in the home of Mrs. Samuel Barrows where Mrs. Barrows extends the most gracious hospitality in the simplest manner. She prepared dinner in her little kitchen 5x7 and seemed to be making no effort. I asked her to tell us something of her experience as a housekeeper. Her successful literary life is all the more charming for her practical knowledge of housekeeping.

How it is done

ISABEL C. BARROWS

Two pictures are in my mind. One is a great Canadian kitchen, with a wood stove whose fathomless maw was never satisfied and whose oven turned out bread black with the raging fires before it was fully baked through. The floor space of the kitchen took an hour or two to scrub; every time a meal was prepared the tired farmer's wife had to walk about a mile between cupboard and table, sink room, or spring house, and stove. That is no exaggeration; it was actual measurement. She would have thought it impossible to spend as much time in walking through the beautiful maple grove.

The product of the kitchen, so far as cooking was concerned, was fried pork for breakfast, griddle cakes fried in lard, doughnuts fried in deep fat, hot coffee and boiled potatoes. For dinner, pork, or in the fall beef, and at certain other seasons veal or lamb; chicken on Sunday, boiled potatoes, turnips, cabbage, pie, green tea and white bread. For supper hot biscuit, cheese, tea, cookies, cake, jelly and a dish of cold beans for "the hired man." That meant hours of cooking, miles of walking, heaps of dishes to wash, a big pile of wood to burn, and several pails of water from the spring, some rods away. There were half a dozen in the family, all dyspeptics and the poor wife was always tired.

The other picture is of an old-fashioned farm house which had a large storeroom opening off from the kitchen. Shelves were on two sides, a door on one and a window on the fourth. An up-to-date man took the old farm. A spring up on the hill was piped and the water brought into this storeroom. A good blue-flame kerosene stove was placed beside it on a zinc-covered table. A small portable oven was hung above it, which could be lowered over the stove when it was needed for baking. Supplies of all kinds for cooking were placed on the shelves, with cooking and serving dishes. The housewife could stand in one spot in that little room and do every bit of her cooking without taking one step. A stool, which when not in use was slipped under the table, was used for all work that she could do sitting down.

The food included no meat, but it was amply nutritious. For breakfast she had only to open a box and take out the chief dish ready for the table, for the preparation was begun the night before. The box was an old chest that had been about a hundred years in the family, strong and close. Inside it was a wash-boiler about which was a close packing of straw, hay and sawdust, so that it was solidly firm with this five-inch wall of packing. A pad of several inches thickness was nailed to the under side of the cover so that when the chest was shut, the cover

of the boiler was protected from the air, as well as the bottom and sides. Just before going to bed the farmer's wife brought water to boil on her blue-flame stove, stirred in oatmeal, grits, cracked wheat, Indian meal, rye meal, or whatever she wanted for breakfast, let it boil ten minutes, put on the cover tight, set it into the boiler in the box, locked the chest and went to bed. In the morning every grain was swollen to its utmost, unbroken, sweet, appetizing. Breakfast was made of bread and butter, this cereal, apple sauce, or prunes or pears, also cooked in the " hay box," baked potatoes and a johnny cake which had baked over the blueflame while the milk was skimmed and the table laid.

For dinner the hay box cooked macaroni, potatoes, carrots, or cauliflower, the white sauce and the steamed eggs, or other food requiring quicker heat, going over the stove. Supper, of farina, cooked in the hay box, with cream, whole wheat bread, cocoa and simple gingerbread, was as easily prepared. The housekeeper had never, in 45 years' experience, used lard. If potatoes were to be warmed in a pan, a bit of butter or a spoonful of table oil, was all that was necessary. Doughnuts, fried things of all kinds were unknown. Pies were made of cream crust and fruit, with no under layer of crust. Fruits of various kinds were supplied and bread of half a dozen sorts. These, with ordinary vegetables gave a wholesome diet, which was enriched by "shellbarks" from the woods and peanuts from the village.

The wood stove, which was kept going in winter, had its hot water tank. In summer the soft water from the roof was quickly heated over the blue-flame stove. The dishes and knives were first wiped with newspaper,—which was kept ready cut in a pile on the shelf—then washed in warm soap and water, placed in a pan, rinsed with actually boiling water, and dried, in almost an instant, without a towel. The one towel used for the glass and silver, was rinsed out at every meal, shaken and dried smooth, so that it was always sweet.

Cooking in this household was made easy, the food was excellent, and the digestion perfect. Instead of walking in the kitchen the good wife walked in the woods, and the breath of wild flowers saluted her nostrils instead of the odor of grease.

Farmers' wives have a hard enough life at best, but the drudgery of preparing food might be greatly lessened if they would believe it.

It is not only in the country that one may learn to economize space and time. In a third story room of a pretty house in Washington a lady has converted a tiny hall bedroom into a miniature kitchen. Within the 7x7 room every appliance of a kitchen is to be found, running water, a stove, oven, cupboard, shelves, stores, tiny ice box, etc.—and the clever lady who presides there says she has only to turn on her heel to provide a five course dinner for herseif, her mother and two friends.

Home Nature-Study Course

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By ANNA BOTSFORD COMSTOCK and JOHN W. SPENCER.

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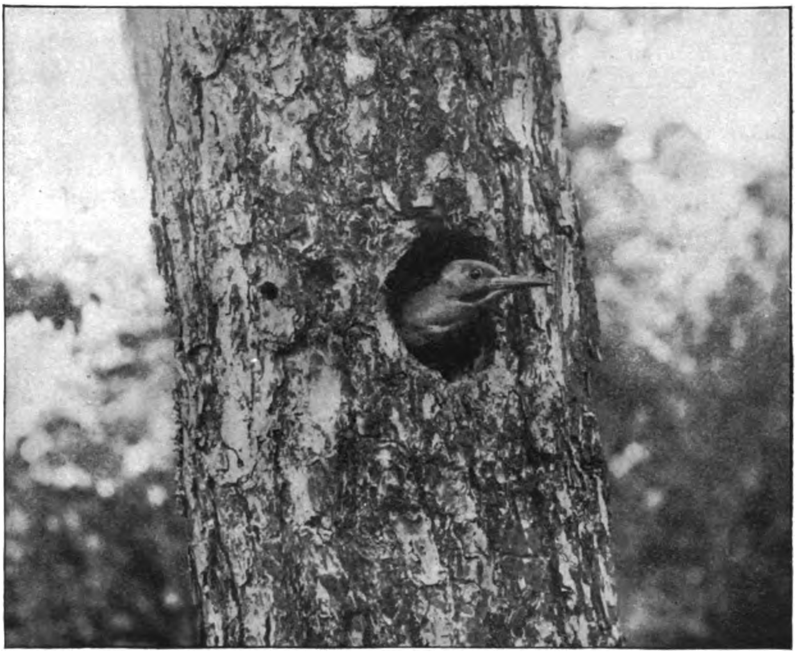

The Flicker. Photo. by Geo. Fiske, Jr

ITHACA, NEW YORK
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AGRICULTURE AT
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"It is a common mistake to attempt to teach too much at every exercise; and the teacher is also appalled at the amount of information which he must have. Suppose that one teaches two hundred and fifty days in the year. Start out with the determination to drop into the pupils' minds two hundred and fifty suggestions about nature. One suggestion is sufficient for a day. Let them think about it and ponder over it. We stuff our children so full of facts that they cannot digest them. I should prefer ten minutes a day of nature-study to two hours; but I should want it quick and sharp. I should want it designed to develop the observing and reasoning powers of the child and not to give mere information. It should be vivid and spontaneous. Spirit counts for more than knowledge.

"Taught in this way, nature-study work is not an additional burden to the teacher, but a relief and a relaxation."

L. H. Bailey, in The Nature-Study Idea.

HOME NATURE-STUDY COURSE,

TEACHER'S LEAFLET.

BASED ON THE FALL WORK FOR THIRD-YEAR PUPILS AS OUTLINED IN THE SYLLABUS OF NATURE-STUDY AND AGRICULTURE, ISSUED BY THE NEW YORK STATE EDUCATION DEPARTMENT.

The editors of the Home Nature-study Course have changed the plan of the nature-study lessons for the coming year in the following respect: In each lesson a number of direct questions are given to assist the teacher in guiding the observations of the pupils. Following these questions the facts which they cover are given for the teacher's reassurance and reference. This plan has been adopted after consultation, and advice from some of the best teachers of the State. However, the editors do not wish it understood that they advise the teaching of nature-study by direct questions and object lessons. The most successful teacher will direct the pupils' observations without much questioning; but it is well that the teacher should have clearly in mind the points she wishes her pupils to cover in a lesson, and the lists of questions given in these lessons are meant to aid in this. The very essence of nature-study is to work with the object or phenomenon itself just where it occurs naturally; but the teacher must first have information about the subject.

The editors ask in return for these lessons that the teachers write something of their experience in giving the work to their pupils.

TWO BIRDS OF THE MEADOW.

Preliminary work.—Two large, brown birds are common in the meadows of New York State from April until the last of October. These are the meadowlark and flicker. They are in nowise related, however, except in their taste for meadow lands. They are approximately the same size and color and each has a black crescent locket on the breast, and each shows the "white feather" during flight. But this last is the chief distinguishing character; the outer tail feathers of the meadowlark are white while the tail feathers of the flicker are not white at all, but there is a single patch of white on the back just in front of the tail. The first work of the teacher may well be to instruct the pupils to distinguish these two birds by these white markings, and next to learn to distinguish them by their flight. The lark lifts itself by several sharp movements, and then soars smoothly over the course, while the flicker has a continuous wave-like flight up and down. Next, the pupils should learn to distinguish the birds by their songs, which are very characteristic.

LESSON I.

THE MEADOWLARK.

Purpose.—To teach the pupil to know these birds from all others; to interest him to discover and appreciate their ways and characteristics.

Observations for pupils:

(1). Color of the head of the Meadowlark.
(2). Color of the line above the eye.
(3). Color of back, wings, tail.
(4). Ground color and ornaments of breast.
(5). Color and shape of beak.
(6). Is it larger or smaller than the robin?

The meadow-lark.

Facts for the teacher.—The color of the black and wings of the meadowlark is brownish, each feather being streaked with black and brownish. The line above the eye is yellow bordered above and below by black. The outer feathers on each side of the tail are white; the sidse of the throat are whitish; the middle throat and breast bright yellow. The "locket" on the breast is a large crescent of black feathers. The beak is long, strong and black. The meadowlark is a little larger than the robin.

LESSON II.

HABITS OF THE MEADOWLARK.

Purpose.—To teach the pupil to observe closely the habits of this bird.

Observations to be made by the pupils:

(1). Where is the meadowlark found?
(2). Describe its flight.
(3). Imitate its note by song or whistle.
(4). Does it sing while on the ground, or on the wing or while resting on a tree or fence post?
(5). Note the date when the first meadowlark is seen in the spring and the last day its song is heard in the fall.
(6) Do the meadowlarks sing during the last of August and through September?
(7). Where is the nest built?
(8). Of what material is it built and how is it hidden?
(9). The color and the number of the eggs.
(10). What are the meadowlark's enemies?

Facts for the teacher.—The meadowlark is found generally in the meadows of New York State and has a particular liking for those that border on streams. Its flight consists of quick up-and-down movements at first and then long, smooth sailing. The song is very beautiful and consists of a sweet, plaintive whistle. It sings when on the ground, while on the wing, and while resting on some high

object. It comes to us early in April and remains until November. It sings all the time except during the moulting period, which occurs in August and September. The nest is built in a depression in the ground near a tuft of grass; it is built of coarse grass and sticks and lined with finer grass; usually there is a dome of grass blades woven above the nest and often a long covered vestibule leading to the nest. This is evidently a protection from the keen eyes of hawks and crows. The eggs are laid about the last of May and are usually from five to seven in number; they are white speckled with brown and purple. The young larks are usually large enough to be out of the way before haying time in July.

LESSON III.

THE USES OF THE MEADOWLARK TO THE FARMER.

Purpose.—To acquaint the child with the value of this bird to the agriculture of the State and to care for its protection.

This work should be in the form of an essay compiled from books, especially the Government Reports.

The food of the meadowlark for the entire year consists almost entirely of insects, which destroy the grass of our meadows. It eats great quantities of grasshoppers, cutworms, chinch bugs, army worms, wire-worms, weevils and also destroys some weed seed. Have each pupil make a diagram showing the proportions of the meadowlark's food. (See Audubon Leaflet No. 3). Teach them that there is a law in New York State that makes the killing of a meadowlark a punishable offense. Use your influence to the utmost to make the pupils understand that this bird is our true friend and that we should encourage its presence in every way possible.

References: Audubon Educational Leaflet No. 3; "Bird Neighbors," Blanchan; "Birds of Village and Field," Merriam; Farmers' Bulletin No. 54, United States Department of Agriculture. Some common Birds in their Relation to Agriculture.

LESSON IV.

THE FLICKER.

Purpose.—To teach the pupil to know the flicker by sight; to interest him to discover and study the individual habits of the bird.

Observations for the pupils:—Describe the color of the flicker as follows:

1. Top of the head.
2. Back of the neck.
3. Throat and sides of the head.
4. Mustache, if present.
5. Breast.
6. Locket.
7. Breast below the locket.

8. Back.
9. Tail and wings above and below.
10. Color and shape of beak.
11. The toes.
12. Size: is the flicker larger or smaller than the robin?

Facts for the teacher.—The top of the flicker's head is slaty-gray and there is a very ornamental band of bright red across the back of the neck; the throat and sides of the head are pinkish-brown; the male has a black mustache extending backward from the beak. The locket is a black crescent, much thinner than that which ornaments the breast of the meadowlark. Below the locket the breast is yellowish-white, thickly marked with circular, black spots. The beak is brown with a white rump which shows only during flight. The wings and tail are blackish above and brilliant yellow beneath. The beak is long, strong and dark colored; the feet have two toes directed forward and two backward like the other woodpeckers. This bird is distinctly larger than the robin.

LESSON V.

HABITS OF THE FLICKER.

Purpose.—To enable the child to be familiar with what the flicker does.

Observations for pupils:

1. When does the flicker first appear in the spring?
2. What is its song?
3. Describe its flight.
4. Does the white patch above the tail show except when the bird is flying?
5. What is the use of this white patch to the bird?
6. Where is the flicker usually found?
7. How many names do you know for the flicker?
8. Where does the flicker build its nest and how?
9. Describe the eggs.
10. How does it feed its young?
11. What is its chief food?
12. How is its tongue fitted for getting its food?
13. To what family does the flicker belong?

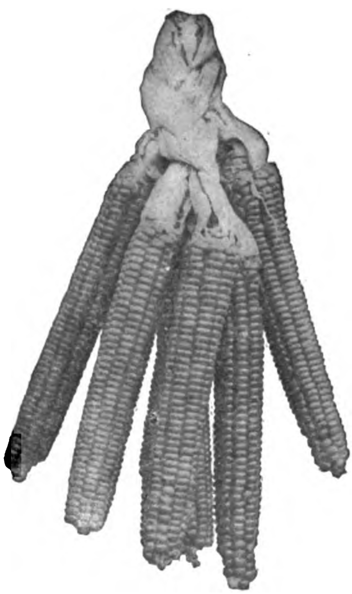
Facts for the teacher.—The flicker first appears early in April or sometimes even in March. Its song is a rapid "wick-a, wick-a, wick-a," and sounds a little like a jolly laugh. It has other notes besides this most common one. Its flight is wave-like and jerky; the white patch shows little or none when the bird is at rest, for this white mark is what the ornithologists have named the "color call." This means when the flickers are migrating in flocks by night this white patch is a rear signal by means of which the flock keeps together and follows the leader. The flicker is not so constantly found in meadows as is the meadowlark, but frequents woods and orchards; it is a bird of many common names in different parts of the

country: Yarup, Golden-winged Woodpecker, High Hole, Clape, and Yellow Hammer are a few of its names. It excavates and builds its nest by chopping out with its strong beak the wood from a tree or post, usually selecting one that is more or less decayed. The hole is quite deep and its opening may be from four to fifty feet above the ground. The eggs may be from four to ten in number; they are white and are laid during the last of May. The parent takes the food into its own stomach and partially digests it; then thrusting its long bill down the throat of the young one it pumps the partially digested food into it "kerchug," "kerchug," until it seems as if the young one must be shaken to its foundations. The chief food of the flicker is ants; it also eats beetles, flies and wild fruit but does little or no damage to planted crops or fruits. So long has this species fed upon ants that the tongue has become modified like that of the ant-eater; it is covered with a mucilaginous secretion and when it is thrust into an ant-hill all of the little citizens in bravely attacking the intruder become glued fast to it and are thus withdrawn and transferred to the capacious stomach of the bird. The flicker is a true woodpecker; its tail is composed of stiff feathers which act as a prop when it climbs a tree; two of its toes are directed forward and two backward in order to enable it to cling more closely to a tree trunk.

References:—Audubon Educational Leaflet No. 5; "Bird Neighbors," Blanchan; "Birds of Village and Field," Merriam; "The Woodpeckers," Eckstorm; "The Food of Woodpeckers," Beal, Bulletin United States Department of Agriculture.

THE MAIZE.

Preliminary work.—This study may be begun in the spring when corn is planted giving the pupils an outline for observations to be made on the plant during its growth; or it may be studied in the autumn as a mature plant. Maize is among the most beautiful and interesting plants in the world; it is native to America, the first white men who came to our shores finding it extensively cultivated by the Indians. Perhaps a good way to arouse the interest of a child in the plant is to tell him how important a part it played during the settling of America by the whites. Had it not been for maize our pilgrim ancestors would surely have starved before they could have cleared off the forests and prepared the fields, so that wheat and rye would have grown in them. They did not need to plow or to clear off forests in order to raise corn; the trees were girdled which killed their tops and let in the light; the rich earth was scratched a little with some primitive tool and the seed put in and covered; the plants took care of themselves and yielded food for the winter needs.



"Yankee" or flint corn, much grown in the northeastern country.

LESSON VI.

THE CORN PLANT.

Purpose.—To lead the pupil to give careful attention to the structure of this plant.

The material necessary is simply a mature corn stalk which may be studied in the field, or pulled up by the roots and studied in the schoolhouse.

Observations for pupils:

1. Describe the central stem.
2. How many joints or nodes are there in it?
3. Of what use to the plant are these nodes?
4. Are the joints or nodes nearer each other at the bottom or top of the plant?
5. Where do the leaves come off the stem and how far do they clasp it at their bases?
6. Of what use is this to the plant?
7. See the little growth on the leaf where it leaves the stalk, which prevents the rain from flowing down between the stalk and the clasping leaf; of what use is this?
8. What is the structure of the leaf and the direction of the veins or ribs?
9. How does this structure aid the plant?
10. Are the edges of the corn leaf straight or ruffled?
11. Of what use is this ruffled edge?
12. Describe the two kinds of roots on the corn plant and explain the use of each?

Facts for the teacher.—In studying the maize it is well to keep in mind that a heavy wind is its worst enemy; such a wind will lay it low and from such an injury it is difficult for the corn to recover and perfect its seed. Thus the mechanism of the corn stalk and leaf is for prevention of this disaster. The corn stalk is practically a strong cylinder with a pithy center; the fibers of the stalk are very strong and at short intervals the stalk is strengthened by the hard nodes and joints; if the whole stalk were as hard as the nodes it would be inelastic and break instead of bend; as it is the stalk is very elastic and will bend far over before it breaks. The nodes are nearer each other at the bottom, thus giving strength to the base; they are farther apart at the top where the wind strikes and where bending and bowing of the stalk is necessary. The leaf comes off at a node and clasps the stalk for a considerable distance, thus making it stronger, especially toward the base. Just where the leaf starts away from the stem is a little growth called the rain-guard; if water should get between the stalk and the clasping leaf it would afford harbor for destructive fungi. The structure of the corn leaf is especially adapted to escape injury from the wind; the strong veins are parallel with a strong but flexible midrib at the center; often after the wind has whipped the leaves severely only the tips are split and injured. The edges of the corn leaf are ruffled and there is a wide fold in the edge at either side where the leaf leaves the stalk; this

arrangement gives play to the sidewise movement without breaking the margins. The leaf is thus protected from the wind whether it is struck from above or horizontally. The true roots of the corn plant go quite deep into the soil but are hardly adequate to holding such a tall, slender stalk upright in a wind storm; thus all about the base of plant are brace roots which serve to hold the stalk erect like the stay-ropes about a flag pole.

LESSON VII.

AN EAR OF CORN.

Purpose.—To induce the pupils to study carefully the flower and fruitage of the corn.

For this lesson there should be a stalk of corn bearing the ripe ears so that the pupils may observe the relation of the ear to the plant.

Observation for pupils:

1. Where are the ears borne? Are two ears borne on the same side of the stalk?
2. Remove an ear and see if the stalk is cylindrical where the ear rested.
3. Examine the outside husks and compare them with the corn leaves.
4. What is there to suggest that the corn husk is a modified leaf?
5. Describe how the inner husks differ from the outer in color and texture.
6. After removing the husks carefully examine the silk and see whether there is a thread for every kernel.
7. Is there an equal amount of silk lying between every two rows?
8. How many rows of kernels are there on the ear?
9. How many kernels in a row? How many on the whole ear?
10. Do any of the rows disappear toward the tip of the ear? If so, do they disappear in pairs?
11. Study a cob with no corn on it and see if the rows of kernel sockets are in distinct pairs.
12. Are the sockets of the paired rows opposite each other or alternate?
13. Break an ear of corn in two and sketch the broken end showing the relation of the cob to the kernels.

Facts for the teacher.—The ears are borne at the joints and the stalk where the ear presses against it is hollowed out so as to hold it snugly; this is very suggestive of a mother holding a baby in her arms. The husks show plainly that they are modified leaves in the following ways: The husk has the same structure as the leaf, having parallel veins; it comes off the stem like a leaf; it is often green, and, therefore, does the work of a leaf; it changes to leaf shape at the tip of the ear, thus showing that the husk is really that part of the leaf which usually clasps the stem. If the husk tipped with a leaf is examined the rainguard will be found

at the place where the two join. As a matter of fact, the ear of corn is on a branch stalk which has been very much shortened so that the nodes are very close together and, therefore, the leaves come off close together. By stripping the husks back one by one the change from the outside, stiff, green leaf structure to the inner, delicate, papery wrapping for the seed, may be seen in all its stages. This is a beautiful lesson in showing how the maize protects its seed, and may well be compared to the clothing of a baby. The pistillate flowers of the corn, which finally develop into the kernels grow in pairs along the end of the shortened stalks which is later the cob. Therefore, the ear will show an even number of rows and the cob shows distinctly that the rows are paired. The corn silk is the stigma of the pistillate flower and, therefore, in order to secure pollen must extend from the ovule, which later develops into a kernel to the tip of the ear where it protrudes from the end of the husks. If the corn silk be examined through a lens early in the season its tips will be seen to be divided into two threads, each covered with short hairs; these are the stigmas on which the pollen falls; and the pollen is obliged to grow down through the whole length of the silk to reach the ovule. A computation of the number of kernels in a row and on the ear makes a very good arithmetic lesson for the primary pupils, especially as the kernels occur in pairs.

LESSON VIII.

THE GROWTH OF CORN.

Purpose.—To give the pupil some points for observing the way that corn grows.

It is always well when the summer vacation comes to give the pupils some work in observation that may be done out-of-doors during the summer. This lesson might begin with the watching of the germination of the corn while the school is still in session and then be continued in the garden or the field later.

Observation on the growth of corn:

1. How does the leaf look when it first comes up?
2. How many leaves are there in the pointed roll, which first appears above the ground?
3. How long before the central stalk appears?
4. When do the tassels first appear?
5. When do the tassels shed their pollen?
6. How large are the ears when the pollen is being shed?
7. Study the corn silk at this period and see the stigmas.

Experiment 1 on corn growth: Compare the growth of a corn plant with that of a pigweed. When the corn stalk first appears tie two strings on the stalk, one just above the joint and one below it. Tie two strings the same distance apart on the stem of a pigweed. Measure carefully the distance between these two strings; two weeks later measure the distance between the strings again.

Experiment 2.—Measure the distance between two of the nodes toward the tip of a corn stalk; two weeks later measure this distance again.

Experiment 3.—When a stalk of corn is still green in August bend it down and place a stick across it at about half its length. Note how it tries to lift itself to an erect attitude after two weeks. Cut lengthwise across one of the nodes beyond the point held down by the stick and see the wedge-shaped growth that occure in the joint which helps to raise the stalk to an upright position.

Experiment 4.—During a drouth in August, if one occurs, note that the corn leaves are rolled. Give such a plant plenty of water and see what happens.

Facts for the teacher.— The first two experiments are to show the pupil that the corn, unlike many other plants, has many places of growth. While young the lower part of the portion that lies between the two nodes or joints is a growing center; also the tip of the stalk grows. In most plants the tip of the stem is the only center of growth. The pigweed experiment will show this. By having so many centers of growth the corn is able to make growth with great rapidity, often achieving in a few months the length of twenty feet. Experiment 3 is to show the wonderful way the corn stalk lifts itself by growing wedges at the joints. A corn stalk blown down by the wind will often show this wedge shape at every point, and the result will be an upward curve of the whole stalk. Experiment 4 is to demonstrate the way the corn protects itself from drouth. The leaves in order to check the transpiration of water roll together lengthwise in tubes, so as to offer less surface exposed to the sun and air. The farmer calls this "the curling of the corn," and it is always a sign of drouth. If a corn plant with the leaves thus curled be given plenty of water the leaves will straighten out again their normal shape.

References: "Corn Plants," Sargent; Cornell Nature-Study Leaflets Vol. I; "The First Book of Farming," Goodrich; "Agriculture," Jackson and Dougherty; "Elements of Agriculture," Sever; "Rural School Agriculture," Hays; "Columbia's Emblem," Houghton, Mifflin.

THE PUMPKIN.

Preliminary work.— Suggest to the pupils that the pumpkin is a member of quite a large family, with several of which they may be acquainted, the squash, watermelon, musk-melon and cucumber being relatives; and that it would be interesting to observe wherein they bear a likeness or differ from each other. Thanksgiving season is an acceptable time for this study because of the stimulus emanating from pumpkin pies.

LESSON IX.

THE VINE.

Purpose.—To lead the pupil to observe the habit of growth of the pumpkin and the way the fruit is developed.

Material.—A part of a vine having leaves, tendrils, both kinds of flowers, and if possible a young fruit. If the crop is grown in the locality these should be readily obtainable, as they cannot mature before frost, and to prune them off is a benefit to the part remaining.

Observations by the pupils:

1. What is the general shape of the leaf? That is, how is it lobed and veined? Is the number of lobes the same on all the leaves?

2. Is the leaf smooth, rough or bristly? Is there a difference in color and texture between the upper and under surfaces?

3. Is the leaf-stem hollow or solid? Ridged or smooth? In cutting it across do you see any strengthening fibers that would help it to uphold the broad leaf? Have you ever seen or made a pumpkin-leaf trombone?

4. How are the leaves arranged on the vine, opposite or alternately?

5. Where do the tendrils spring? Are they branched or single? Do they twine left to right, right to left, or both ways?

6. Is the main trunk of the vine solid or hollow, ridged, smooth or bristly?

Facts for the teacher.—Pumpkins leaves are mostly three and five-lobed, and dark, dull green. The whole plant is rough and bristly. It is a very thirsty plant and its forests of bristling hairs enable it to catch and retain more dew and other moisture and also enables it to preserve the moisture from loss by radiation better than if it were smooth.

Emphasize the principle in mechanics that a hollow tube will bear greater stress than the same amount of material in a solid cylinder, and that it is exemplified in the pumpkin-leaf stem.

The leaves are arranged alternately and the blossoms and tendrils spring from their axils. The branching tendrils twine in all directions, sometimes twisting backward into knots.

LESSON X.

THE FLOWERS.

Purpose.—To help the child to see that often very common things are exceedingly beautiful; also to know how necessary is the help of insects to some plants as pollen-carriers.

Material.—A staminate and a pistillate blossom.

Observations by the pupils:

1. Describe as well as you can the shape, color and veining of one of the flowers.

2. Do you see any difference between the two blossoms?

3. On which will the fruit begin to grow?

4. What, then is the use of the other flower?

5. The golden vases are deep and held upright. How is pollen to pass from one to the other?

Facts for the teacher.—If pumpkin blossoms were rare and difficult to grow, they would be cultivated for their beauty alone. Note the clear, golden color, the veining, and the graceful curves of the five-lobed corolla. Call attention to the long and slender stem of the staminate flower, and the short and sturdy one of the other, with its little pumpkin all ready to begin growing, as soon as the seeds are wakened to growth by help of pollen from its neighbor blossom. Show that

the plant is helpless to accomplish this without aid from bees and other insects. The three stamens are united in a little club in the bottom of the flower and against it each visiting insect bumps itself, getting well dusted with pollen which it rubs off on the three two-lobed pistils which it finds in the other blossom.

LESSON XI.

THE FRUIT.

Purpose.—To interest the pupil in the value of the fruit as food for men and animals.

Material.—A ripe pumpkin.

Observations by pupils:

1. Describe as well as you can the appearance of the fruit. Count the ridges; do the numbers of ridges vary on different pumpkins?
2. Is the stem solid or hollow? Smooth or corrugated?
3. What made the round, brown blotch opposite the stem?
4. Tell how the seeds are arranged in their case. Do they point toward the center or the outside? How are they held in place?

Facts for the teacher.—A tree bearing fruit as large and heavy as this would need to be very sturdy and strong. Show how the vine saves strength by letting the earth support its fruit, so that it is able to devote most of its energies to making it grow. Its solid, corrugated stem, knobbed at the point of attachment is very different from the smooth, round one of the squash. The blotch opposite the stem shows where the blossom fell away. The number of ridges vary. The writer has counted as many as thirty-nine on one big pumpkin and as few as fifteen on another.

Inside the thick, shining, yellow shell lies the solid, meaty portion which is used for pies; next, and packed loosely about the seed compartment is a mass of stringy pulp. There are three divisions of the seed compartment, in each of which there are two stacks of seeds, placed one above another in layers of three. Note that the point of attachment of the seed is on the outside wall of the compartment.

The seeds themselves are flat, oval, pointed, strengthened by a thickened ridge about the edge, but peeling easily, and the plump starchy meat within is palatable.

The chief value of the crop is as food for milch cows; it causes a yield of milk so rich that the butter made from it is golden as its flesh. But the Hallow-e'en jack-o'lantern appeals to the children. In this connection a study of expression might be made interesting; the turning of the corners of the mouth up or down and the angles of the eye-brows making all the difference between a jolly grin and an "awful face."

References: "Cyclopedia of Horticulture," Bailey; "Farmers' Cyclopedia of Agriculture," Orange, Judd & Co.

THE TURTLES.

Preliminary work.—The occasion for this lesson should be when pupils find a turtle or when one is introduced into the aquarium. We have inland in New York State several turtles, any one of which will do for this lesson. The following are our most common species:

(a) *The Snapping Turtle.* This sometimes attains a shell 14 inches long and a weight of 40 pounds. This is a vicious creature and can inflict a very severe wound with its sharp, hooked mandibles. It will, by stretching its long neck, strike like a snake with lightning rapidity and is a dangerous creature to handle; it should not be used for a nature-study lesson unless the specimen is very young.

(b) We have two true Mud Turtles, the *Musk Turtle* and the *Common Mud Turtle;* they both inhabit slow running streams and ponds and are truly aquatic, never coming to the shore except to deposit their eggs. They cannot eat unless under water and seek their food in the muddy bottoms of streams and ponds. They may be distinguished by the following characteristics: The upper shells of both are brown. The Musk Turtle when handled emits a very strong odor, and it has on each side of the head two bright yellow stripes, which extend from the tip of the snout to the neck. The Mud Turtle does not emit the strong odor, and its head is ornamented with greenish-yellow spots.

THE TERRAPINS.

These turtles are partially aquatic and spend much of their time on logs or other objects projecting from the water and always take to the water to escape attack.

(c) *The Painted Terrapin or Pond Turtle.* This can always be determined by the red mottled border of its shell. Its shell rarely reaches a size beyond 6¾ inches. This turtle makes a good pet if kept in an aquarium by itself, but will destroy any other creature kept with it. Its aquarium should be provided with a stick or a stone projecting above the water so that it can climb out if it chooses. It will eat beef or chopped fish and is fond of earth worms and soft insects.

(d) *The Spotted Turtle.* This has the upper shell black with numerous round, yellow spots upon it. It is common about ponds and marshy streams and is a sociable creature, being often found with several of its fellows on a log, from which it dives for safety when disturbed. This species always feeds under water eating insect larvæ, dead fish, and probably vegetation. In captivity it will eagerly eat fresh lettuce.

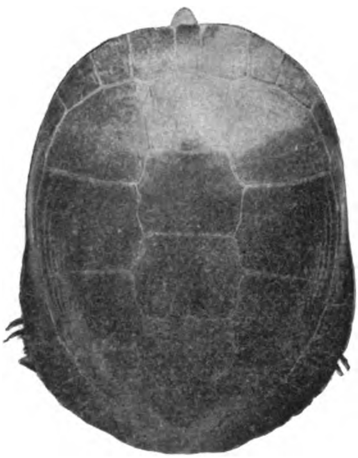
(e) *Muhlenberg's Turtle.* This is found along the Hudson and its southern tributaries. Its upper shell is about four inches long and is not decorated with yellow spots. The head is black with a large patch of brilliant orange-yellow on either temple. It is not so aquatic as the Spotted Turtle but like it walks about in the marshes. It feeds out of water, eating tender green leaves, insects and earth worms. In captivity it will eat chopped meat, lettuce and berries.

(f) *The Wood Terrapin.* This is our most common turtle found in damp woods and wet places; it lives largely upon the land. Its upper shell often reaches the length of 6½ inches and is made up of many plates or shields ornamented with concentric ridges. This is the turtle upon whose shell people carve initials and dates and then set it free. All the fleshy parts of this turtle, except the top of the head and the limbs, are brick red. It can swim but prefers to live on land. It feeds on tender vegetables, berries and insects. It makes an interesting pet and will soon learn to eat from the fingers of its keeper. It may be fed berries, lettuce, chopped meat, fish and beetle larvæ.

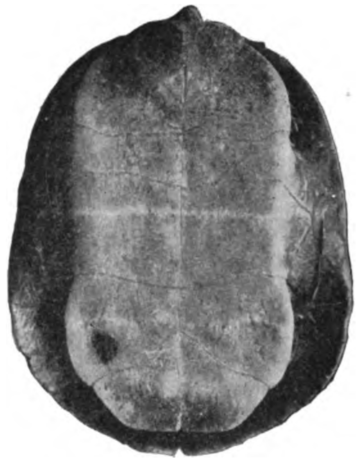
(g) *The Box Turtle.* This is easily distinguished from the others because the front and rear portions of the lower shell are hinged so that they can be pulled up against the upper shell. When the turtle is attacked it withdraws into the shell and closes both the front and the back door, and there it is in its box safe from all enemies. This turtle lives entirely upon land and feeds upon berries, tender

vegetation and insects. It lives to a great age, and its shell often bears carved initials and dates.

(h) *The Soft-shelled Turtles* may be found in New York along the tributaries of the Alleghany and St. Lawrence rivers and also in the Erie Canal. These may be distinguished easily as the upper shell looks as if it were all of one piece and of a soft leather-like consistency and looks like a pancake. However, the Soft-shelled Turtles are not soft tempered and snap viciously when cornered.



Carapace of the Painted Terrapin.



Under view of the same.

LESSON XII.

THE APPEARANCE AND HABITS OF A TURTLE.

Purpose.—To call the attention of the pupil to the structure and habits of the turtle.

Observations for pupils:

1. Compare the upper shell with the lower shell in the following ways: Size, shape, color.
2. Make a drawing of each showing the different plates of which it is composed.
3. Is the border of the upper shell different from the central portion in color and markings?
4. Is the edge smooth or scalloped?
5. When the turtle is withdrawn in the shell how much of it projects beyond the upper shell?
6. How much from the lower shell?
7. Describe the markings on the head of the turtle.
8. Describe the eye.
9. How is it protected?
10. How does the turtle wink?

11. Note the nose and nostrils.
12. Describe the mouth.
13. Are there any teeth?
14. Describe the movement of the throat when breathing.
15. What is the shape of the leg? How is it marked?
16. How many and what kind of class on the front feet?
17. Are the front feet webbed? If so what for?
18. Describe the tail.
19. What becomes of it when the turtle withdraws in its shell?
20. How much of the body can you see and how is it colored?
21. What are the turtle's enemies?
22. How do they escape from them?
23. Do all turtles live in water?
24. Upon what do turtles feed?
25. How do turtle's eggs look?
26. Where are they laid?

Facts for the teacher.— In the scientific books the upper shell of the turtle is called the Carapace and the lower one the Plastron. If you can teach the pupils these names incidentally it will help them in their reading. There is much difference in the different species of turtles in the shape of the upper shell and the size and shape of the lower shell. In most species the Carapace is half-globular, in some it is quite flat. The upper shell is grown fast to the backbone of the animal and the lower shell to the breast-bone. The markings and color of the shells offer excellent subjects for drawing. The turtle has no eyelids like our own, but it has a nictitating membrane, which comes up from below and completely covers the eye. If you seize the turtle by the head and attempt to touch its eyes, you will see the use of this eyelid. When the turtle winks it seems to turn the eyeball down against the lower lid. The sense of smell in turtles is not well developed, as may be guessed by the very small nostrils, mere "pin holes." The turtle's mouth is a more or less hooked beak and is not armed with teeth but with cutting edges. The movement in the throat is caused by the turtle swallowing air or breathing. The color of the shell and turtle itself differs with different species; (the common painted turtle is the most interesting to study, for it is beautifully mottled and spotted with red and yellow). The legs are so large and soft that they do not seem to have any bones inside; however, the skeleton shows that the bones are there. The claws are long and strong; there are five claws on the front feet and four on the hind feet. Some species have the web between the toes much more developed than do others, depending upon whether most of the life is lived in the water or out of it. The enemies of turtles are the larger fishes and other turtles. Two turtles should never be kept in the same aquarium, or they will eat each others legs and tails off with great relish. The children should be made especially interested in the wonderful growth of shell for the protection of the turtle. In the case of the box turtle this is complete, and in the case of the others is sufficient to protect them from most of their enemies. Turtles feed upon insects, small fish, or almost anything soft-bodied that they can catch in the water; they are especially fond of earth worms. The species which frequent the land feed upon tender vegetation and also berries. In the aquarium a turtle should be fed earth worms, chopped fresh beef, lettuce leaves and berries. The aquarium should

always have in it a stone or some other object which projects above the water, so that the turtle may climb out if it chooses. In the winter turtles bury themselves in the ooze at the bottom of ponds and streams. Their eggs have white, leathery shells, are oblong in shape, and are buried by the mother in the sand at the edge of the stream or pond. The long life of turtles is a well authenticated fact, dates carved upon the shells showing the age of thirty or forty years.

References: "The Reptile Book," Ditmars; Text-Books, Jordan, Herrick, Kellogg, Needham.

THE MONARCH BUTTERFLY.

Preliminary work.—This lesson should be given in September as soon as school opens while yet the caterpillars of the monarch are feeding upon the milkweed, and while there are yet many specimens of this gorgeous butterfly to be seen. Perhaps the first observation should be the lazy flight of this very striking butterfly; its flight shows clearly that it is not at all afraid of birds, while the zig-zag and dodging flight of other butterflies suggests very forcibly the way these insects escape from their bird enemies.

Monarch butterfly.

LESSON XIII.

THE APPEARANCE OF THE MONARCH BUTTERFLY.

Purpose.—To cause the pupil to observe closely the colors and the marks of the monarch.

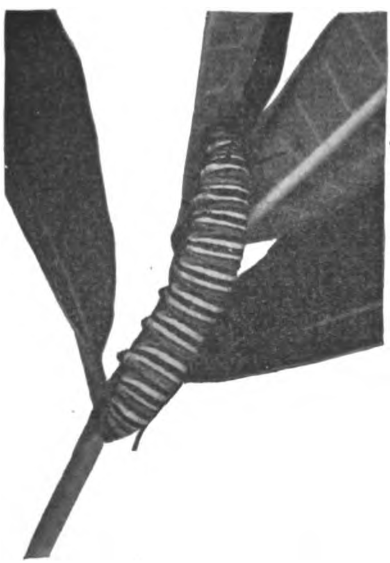
Observations for pupils:

1. What is the ground color above?
2. Where are the black markings on the wings?
3. Describe the positions of the white spots on the wings.
4. Describe the colors and marks on the lower sides of the wings?
5. what is the color of the body, and describe the white marks upon it?
6. Describe the antennæ.
7. How many legs has this butterfly?
8. Is there a black spot near one of the veins on the hind wing? If so, tell what it is for?
9. Is the color of this butterfly very striking? If so of what advantage is this to the butterfly?

Facts for the teacher.—The brilliant copper-red color of the upper sides of the wing of the monarch is made even more brilliant by the contrasting black markings which outline the veins and border the wings, extending back from the tips of the front wings in a triangular patch, which seems to be made especially for showing off the pale orange and white dots set within it. The white dots are set two pairs in two rows between each two veins in the black margin of the wings, and the fringe at the edge of the wings shows corresponding white marks. Below the hind wings and the front part of the front wings have a ground color of pale yellow. The black veins on the hind wing are outlined with white and the white spots are much larger on the lower side of the wings than on the upper. The antennæ are about two-thirds as long as the body and each ends in a long knob. The body is black, ornamented with a few pairs of white spots above and with many large white dots below. Insects have six legs and this is one of the characters of the order, but in this butterfly the front pair have become so small through disuse that they scarcely look like legs and are folded up under the head. In the monarch butterfly the male has a black spot upon one of the veins of the hind wing. This is a perfume pocket and is filled with what are called scent scales; that is the scales which cover the wing in this place give forth an odor, which we cannot perceive but which is very attractive to the females of the species, so this butterfly may be described to the children as a dandy that carries a perfume pocket to attract his sweetheart. It would be a good exercise to let the children see a bit of a butterfly's wing through the three-fourths objective of a compound microscope, so that they may observe the beautiful covering of scales. The monarch is for some reason distasteful to birds; therefore, its brilliant color is a warning to them that this is a butterfly that they had best let alone.

LESSON XIV.

THE MONARCH CATERPILLAR.



Larva of monarch butterfly.

Purpose.—To familiarize the pupil with the form, colors and habits of this caterpillar.

Observations for pupils:

1. What are the colors and markings of the caterpillar?
2. Note the whiplash-shaped filaments on the caterpillar and describe where they are situated?
3. Do these move as the caterpillar walks or when it is disturbed?
4. Of what use can they be to the caterpillar?
5. Upon what plant does the caterpillar feed?
6. Place it upon some other plant and note if it will feed upon it.

7. Does it feed upon the upper or lower surface of the leaves?
8. If disturbed what does the caterpillar do?
9. When it is down in the grass how do its cross stripes protect it from observation?
10. Does the caterpillar feed during the night as well as by day?
11. When resting does it hide beneath the leaf?

Facts for the teacher.—The milkweed caterpillar is a striking object and when fully grown is about two inches long. Its ground color is green with cross-stripes of yellow and black. On top of the second segment back of the head are two, long, slender whiplash-like organs and on one of the rear segments is a similar pair. When the caterpillar is frightened the whiplashes on the front of the body twitch excitedly; when it walks they move back and forth. Those on the rear end of the body are more quiet and not so expressive of caterpillar emotions. These filaments are undoubtedly of use in frightening away the little parasitic flies which lay their eggs upon the backs of caterpillars and the young of which feed upon the non-vital organs and bring about death through weakening their victim; the whiplashes serve to brush off and drive away these rascally intruders. The caterpillar will feed upon no plant except milkweed; it feeds both by day and night with intervals of rest, and when resting hides beneath the leaf. When disturbed it drops to the ground where its fine cross-stripes render it quite invisible among the blades of grass.

LESSON XV.

THE MONARCH CHRYSALIS.

Purpose.—To call the pupil's attention to the beauty of color and form of this living gem.

Observations for pupils:

1. What is the shaps of the chrysalis?
2. What is its color?
3. How and where is it ornamented?
4. Which part covers the wings of the butterfly?
5. To what is the chrysalid attached?
6. Is it in a position where it does not attract attention?
7. How is it attached to the object on which it is hung?
8. How long after the chrysalis is formed before the butterfly emerges?
9. Does the chrysalis change color as the time draws near for the butterfly to emerge?

Chrysalis of the monarch butterfly.

Facts for the teacher.— The monarch chrysalis is a short, plump, oblong, little object of the most exquisite green color. It is ornamented with gold and black tubercles and has a band of gold on the back of the third segment of the abdomen. It is one of the most beautiful objects in nature, and should be made a means of æsthetic enjoyment to the child. It is attached to a button of silk by a little, black knob. As this chrysalid is usually hung to the under side of a fence rail or to an overhanging rock, it is usually surrounded by green vegetation, so that its green color is a protection in hiding it from prying eyes. Yet it is hardly from birds that either caterpillar or chrysalis hides, because to most birds this insect is distasteful in all its stages. As it nears time for the butterfly to emerge the chrysalis changes to a duller and darker hue. The butterfly comes out about twelve days after the caterpillar changes to a chrysalis.

References: "Everyday Butterflies," Scudder; "How to know the Butterflies," Comstock; "Moths and Butterflies," Dickerson; "Ways of the Six-Footed," Comstock.

THE HORSE-CHESTNUT.

Preliminary work.— This beautiful shade tree is especially interesting to girls because of the beautiful flowers and to boys because of the nuts, which have been from time immemorial boys' "legal tender." They might be more interested in the tree if they knew that the species is not native to America. It was introduced from Europe about 150 years ago; the first tree planted is said to be still standing on a country estate near Yonkers, N. Y. The horse-chestnut is a native of southern Asia and is found in the high mountains of northern Greece.

LESSON XVI.

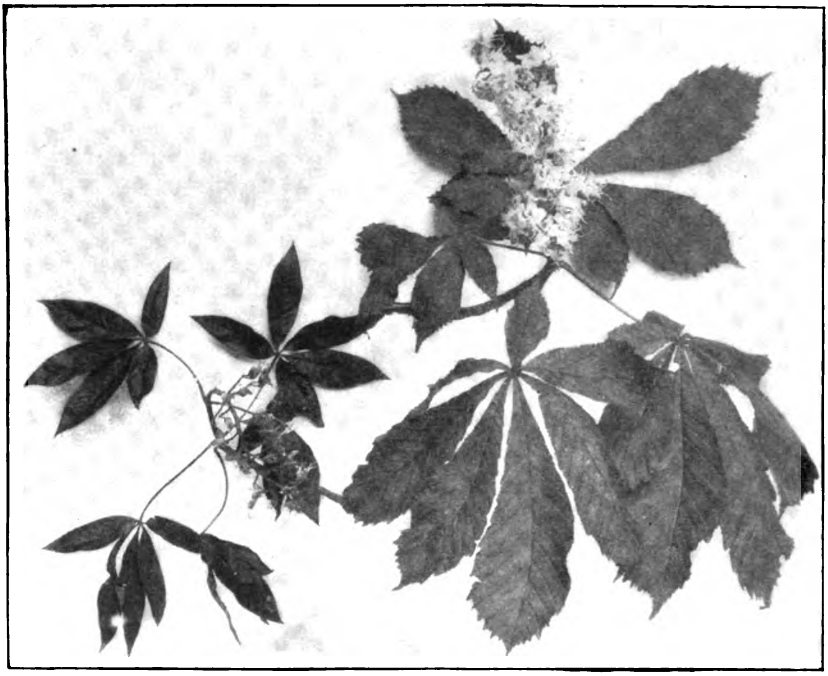
THE TREE, ITS CHARACTER AND SHAPE.

Purpose.—To draw the pupil's observation to the fact that trees have characteristic shapes and habits of growth which aid in their identification at any season of the year.

Observations by the pupils:

1. What is the shape or general outline of the tree?
2. Is the foliage thickly massed or open and light?
3. Is the coloring light and delicate, or heavy and dark, giving an impression of dense shade?
4. Is the trunk smooth, or fissured and corrugated?
5. What is the general color of the bark on the trunk and large branches?
6. What is the color of the younger branches?
7. What is its habits in branching? Does the trunk divide and spread at the lower branches, or extend far upward with short side branches?

Facts for the teacher.— If possible take the class in a body to visit a well-formed, typical horse-chestnut tree. Call attention to its pyramidal shape. It has been well described when in bloom as "A pyramid of green supporting a thousand pyramids of white!" Observe its density of foliage. When walking towards



Ohio Buckeye. Horse-chestnut foliage and flowers.

a thrifty tree with the sky at its back, it seems a solid mass of dark, rich green with but few chinks of light.

Note the brown bark of the trunk and its tendency to break into plates. Younger branches are lighter or grayish-brown. In the buckeyes, young bark has a yellowish tinge. Although the lower branches are large and sturdy, it does not divide out in the fan-like way of the maple, but builds its pyramid by lifting its trunk well toward its apex.

LESSON XVII.

THE LEAVES.

What they do for the tree; What they do for mankind.

Preliminary work.— Before taking up the horse-chestnut leaf in particular, give a short lesson on leaves in general; that it is by the action of the green leaf-cells that trees and all other plants are able to assimilate their food. Many tons of "crude sap," as the food-laden moisture is called, which is gathered by the roots from the soil, are carried up to the leaves, where much of it is given off in transpiration, thus moistening, cooling and purifying the air. But the mineral food which is carried is retained in the green leaf laboratories, is combined with the gases in the atmosphere, and by the power of the sun's light and heat is transformed largely into starch, which is the only form of plant-food available for the making of new growth. All green leaves are starch factories and it is through the working of this miracle, year by year, that the whole world is fed.

Purpose.—To secure from the children as accurate observation and description as possible of the shape, color and markings of this leaf, and to help them to realize in some degree the value of all leaves.

Material.—A leaf or twig on each pupil's desk.

Observations for pupils:

1. What is the general shape of the whole leaf?
2. Is the stem in its center?
3. Do all the leaves have the same number of leaflets?
4. Do you find any leaves with an even number of leaflets?
5. What is the shape of the leaflets?
6. Are they narrowed at base or tip?
7. Are their edges toothed or even?
8. Are their veins straight or branching; large and prominent, or slight and unnoticeable?
9. Is the surface of the leaves smooth, or rough, or hairy?
10. Is there much difference between the appearance of the upper and under sides of the leaf?
11. What is the character of the stem: slender and pliant, or very stiff and strong? Do they taper or grow larger at the point where leaflets are attached?
12. Break a leaf-stem. Is it green throughout? What can you see in the center?
13. Is there anything at the base of the stem, between it and the twig on which it grew? What do you think it may become next season?
14. Do the leaves grow on opposite sides of the twigs or alternately?
15. What color do they turn in autumn?
16. When they fall do they drop entire, or do leaflets and stem fall apart?

Facts for the teacher.—When laid flat the general shape of the leaf is nearly circular, but the two outer leaflets nearest the stem are much smaller than the others, the next pair are intermediate in size, while the three between are about equal, though often the central one is largest of all. This arrangement brings the stem far to one side of the circle. Occasionally a stem bearing six leaflets is found, but more often the division is three, five, seven or nine, the majority being seven. The shape of the leaflet is a reversed oval, the stem being attached at the smaller end. Their edges are irregularly toothed, and the veins are large, straight and lighter in color than the rest, so that each leaflet has a strongly ribbed appearance. The upper surface is smooth and very dark green, while the under side is slightly roughened and is lighter in color.

The stem is long, strong, cylindrical for most of its length, but enlarging both where it is attached to the twig and at its junction with the leaflets. When cut or broken across it shows a woody outer part encasing a white pith and in the center may be plainly seen, even with the unaided eye, a bundle of strong fibers as many in number as the leaflets. These hold the leaflets to the stem and the stem to the twig; also they are channels by which the sap is carried from the twigs to the leaves. At the base of the stem is a bud which begins to form as soon as the flowers

fall and the leaves attain their growth. So the leaves are performing many tasks at once; sending the starch which they manufacture to be stored in the forming buds, in the growing nuts, in the living and increasing wood, and in the roots. Note that this year's fruit and next year's flowers are at the same time provided for.

The leaves grow on opposite sides of the twig and stand out stiffly from it at a wide angle; the whole expression of the tree is stiff and prim; very dignified and stately but not graceful.

The prevailing color of the leaves in autumn is dull yellow, but there are brown tints. They "go all to pieces," as they fall, the separation being as complete and the joint as smooth between leaflets and stem as between stem and branch.

LESSON XVIII.

THE FLOWER.

Purpose.—To acquaint the child with the different parts of the flower, and to show how the bees and other insects help by carrying pollen.

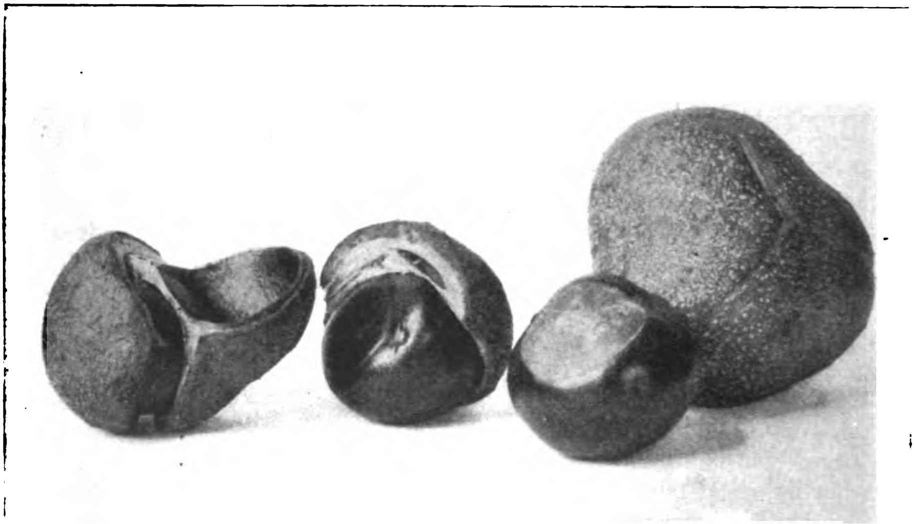
Material.—At least two flowers on the desk of each pupil, and as large and fair a spike as can be obtained in the hands of the teacher.

Observations by the pupils:

1. On what part of the tree are the flowers borne; at the ends of the twigs or at side shoots?
2. Do the clusters droop or stand stiffly upright?
3. What colors do you see in the flowers?
4. How are the separate flowers arranged on the main flower stalk; opposite, alternately or spirally?
5. Do the flowers all open at once, from top to bottom of the spike?
6. Describe the calyx or green cup in which the flower rests; number its parts; tell whether it is smooth and shining or soft and hoary as though covered with minute hairs.
7. How many petals are there? Are they alike in size and shape? Are they attached or connected with each other?
8. How many stamens? Are they held within the corolla, or do they protrude beyond its edge?
9. What color are the anthers or pollen-boxes?
10. Search the center of the flower. Do you find a single, stiff, green pin, with a sticky tip, springing from a round seed-box in the heart of the flower? This is the pistil. Can you find one in every flower?
11. Is the flower fragrant?
12. Have you observed any insects visiting the flowers?
13. Study the flower again. Could a bee enter it and get the nectar at the base of the blossom without touching the tip of the pistil? Could it withdraw without dusting itself with pollen from the out-thrust anthers?

Facts for the teacher.—The horse-chestnut blossom grows only in the terminal buds, and the production of flowers and fruit stops the growth of the twig at that point. It is continued by the side or lateral buds, and this makes a forking branch.

Explain that this habit is one of the reasons for the thick growth of foliage. Each blossom-spike stands erect as a candle-flame and the flowers are arranged spirally around its stalk. They are creamy white or tinged with pink, and have yellow and purple blotches in their throats. The calyx is five-cleft and it and its pedicel are covered with a soft dress of shortest, finest hair. Five spreading and unequal petals are raised on short claws to form the corolla, and seven stamens with orange-colored anthers are thrust well beyond their ruffled borders. Not all the flowers have pistils and many that do are imperfect. Most of the pistillate flowers are near the bottom of the spike where the stem is stoutest and best able to bear the weight of the heavy nut. The flowers are fragrant and are constantly visited by bumble-bees, honey-bees and wasps. White flowers which are also fragrant are usually attractive to night-flying moths.



Fruits or seeds of the horse-chestnut.

LESSON XVIX.

THE FRUIT.

Purpose.—To lead the pupil to think of the nut as containing the seed of the tree and of its provision of food for the young seedling.

Material.—Nuts in their husks for each pupil and for the teacher.

Observations by the pupils:

1. What is the shape of the nut in its burr?
2. Into how many parts does the husk divide when it opens?
3. Describe the husk; its outside; its lining.
4. How many nuts are there usually in a burr? Describe their shape, their color and markings. Which make the best "Conquerors," those which grow singly in a burr, or twins?
5. Open the nut. Can you find any division in the "meat"? How does it taste?

Facts for the teacher.—The prickly, spherical fruit of the horse-chestnut fits well with its other characteristics of stiff regularity. An unbroken husk is really pretty, with its white satin lining, its three-parted opening and its prickly outer coat. The reason for such protection is hard to find, for the nuts are uneatable, being very bitter. Squirrels leave them untouched, though it is said that hungry deer will eat them. In former times a cough medicine for horses and cattle was made from them; and crushed and mixed with fat, they made an astringent salve.

If the very young nuts are cut across, each is seen to contain six tiny seeds, but they are never all developed; usually only one or two come to full size. They are somewhat oily and when dried make a hot and quite lasting fire. The writer once knew a poor family whose children gathered them in bushels from the city streets to be used for this purpose when coal was dear.

HORSE-CHESTNUT BUDS AND TWIGS IN WINTER.

Purpose.—To lead the child to observe the records which the tree has made of its past growth, and its provision for the growth of the coming summer.

Material.—Unless horse-chestnut trees are very numerous it would be a wrong to despoil them of twigs enough for each pupil to have one. Several large twigs may be passed about during the lesson, and afterwards they may be placed in a jar of water in a sunny window and their development watched.

Observations by the pupil:

1. Are the buds on the twigs all nearly alike in size? If not, where are the larger ones situated?
2. What is the color of the buds?
3. How are the scales arranged on them?
4. Describe the appearance of their surface.
5. What do these gummy scales enfold? Can you tell without opening them which contains a flower-bud and which holds only leaves?
6. Observe the scars on the twig just below the buds. What do you think made them? Describe their shape and any marks on them. Do you think their horse-shoe form may have helped in giving the tree its common name? What made the "nail heads?"
7. Has the twig any other scars?
8. What made the double ring just above the next pair of "horse-shoes" further down on the twig?
9. Do these two sections seem to be alike in color, size and thickness of bark? What do you think is the difference in their ages?
10. Make a smooth slanting cut across the end section of the twig and then of the older one below. Describe the difference or draw a picture of each if you can.
11. Describe any other marks which you see on the bark.

Facts for the teacher.— In such a lesson a magnifying glass is of great assistance, and it may be had very cheaply — from fifty cents up. But even without one, the pair of woolly, folded leaves, and the spike of undeveloped flowers may be distinguished in the large, terminal buds of the horse-chestnuts. The side buds contain only leaves. The scales overlap each other in opposite pairs on four sides of the twig and seem to be covered with brown varnish which is very sticky to the touch.

Below each bud on the twig is a scar of horse-shoe-form studded with tiny dots, like nail heads. These show where leaves were attached in a previous season, and the "nails" indicate the number of leaflets, for they are made by the bundle of fibers which pass through the center of the leaf-stalk, and connect the twig with each individual leaflet. Beside the leaf-scars, the falling away of the bud-scales each year leave ring-like marks which show where they were attached. The difference in appearance between the last section and that which is a year older is very distinct, the bark being darker and the scars less plain. When cut across, the youngest part shows only a woody envelope with a white, pithy center; older sections show annual rings. Many little dots of lighter color than the bark may be observed scattered over the twigs. Under the lens they are seen to be fissnres or openings in the bark. They are the lenticels or breathing pores.

Some of the largest twigs should be forced in water for the sake of easy observation of the unfolding leaves; their soft coloring, and the swift uplifting of the tiny tents is a sight not soon to be forgotten.

Our native species the Ohio Buckeye and the Sweet or Big Buckeye, are also beautiful trees and are somewhat common, so that comparisons between them and the immigrant horse-chestnut may be made very interesting.

References: "The Tree Book," Rogers; "Guide to the Trees," Lounsberry; "Familiar Trees and Their Leaves," Mathews.

THE DAHLIA.

Preliminary work.—Give some history of the flower. It is a native of Mexico and Central America, where it is still an abundant wild flower. It was first grown in Europe in 1789. It was named in honor of Professor Andreas Dahl, a Swedish pupil of Linnæus. The first cactus dahlia was grown about forty years ago from a Mexican tuber which had been imported by a Dutch dealer in bulbs. It was named for President Juarez of Mexico, and from that one plants all others of the kind are descended.

LESSON XXI.

THE PLANT.

Purpose.—To draw the observation of the pupil to the fact that plants are related to each other, and that very gorgeous ones often have homely relatives that may be harmful to man's interests.

Material.—An entire plant with tuber attached, if obtainable; if not, one or two "toes" may be taken without injury to the plant by digging down and carefully cutting them away without stirring the main clump. Some of the dahlia's poor relatives, like the wild sunflower and the pitch-fork weed, should be brought in for purposes of comparison.

Observations by pupils:

1. Can you tell by its appearance to what great plant-family the dahlia belongs?

2. Do you know any common flower which has ray florets and a central disc like the single dahlia?

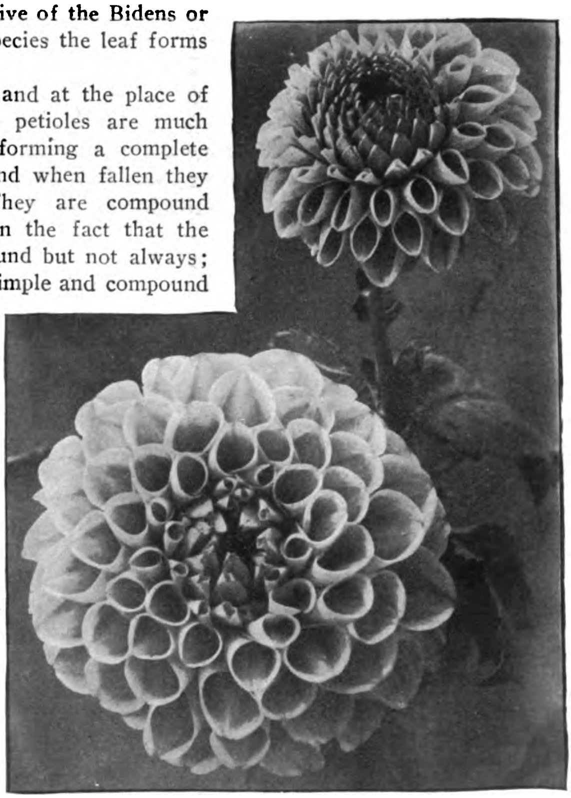
3. Compare the leaf with that of the beggar-tick or pitchfork weed. Should you not guess from their appearance that they are near relatives? In what are they alike, and how do they differ?

4. Do the leaves of the dahlia grow on opposite sides of the stalk or alternately? Are they simple leaves or compound? Do you observe anything remarkable in the way the leaves are attached to the stem?

5. Study the tuber. Has it "eyes" from which shoots may grow? Is it an underground stem like the potato? If it has no eyes and is severed from its crown, do you think it can grow?

Facts for the teacher.—Show the children by direct observation—by use of a lens, if it can be done,—that some flowers that appear to be only one, are really whole collections of blossoms living on one stem; and the dahlia belongs to this, the "Composite" family. The fact can be brought out best by a "single" flower. The dahlia is so close a relative of the Bidens or beggar's tick, that in some species the leaf forms seem almost identical.

The leaves are opposite and at the place of attachment to the stalk the petioles are much dilated so that they unite, forming a complete ring about the main stem, and when fallen they leave a ring-like scar. They are compound leaves and are remarkable in the fact that the leaflets also are often compound but not always; a single leaf may have both simple and compound leaflets. Observe the groove on the upper side of the midrib, down which the rain and dew is carried to the roots of the thirsty plant. The root is a crown tuber and does not put forth side buds like the potato. "Toes" without crowns cannot form new plants.



A full double dahlia.

LESSON XXII.

VARIETIES OF DAHLIAS.

Purpose.— To show how greatly the forms of plants may be changed by careful choice and cultivation.

Material.—One each of all the different kinds of dahlias that are to be hăd. Single ones of both cactus and flat-rayed type; double cactus dahlia; "fancies," which have always more than one color;

Observation by the pupils:

1. Describe all the kinds of dahlias in the schoolroom or garden as to size, color, number of petals, shape.

2. Among all the wild flowers of your acquaintance, do you know any double ones?

3. Is there any familiar double flower of your gardens whose wild relatives you know to be single?

4. Do you know any double flowers of any kind which form seed after blooming?

Facts for the teacher.— Tell how the double flowers do not occur in nature, but are slowly brought to such a state by saving the seeds of such as were noticed to have a few extra petals, cultivating with care, usually giving an excess of food, and so encouraging the habit through many generations. Many country children may be able to compare the wild rose, wild sunflower, meadow buttercup, and wild pink, with cultivated flowers of the same name which they observe to be double. Usually double flowers have few or no seeds, though there are exceptions like the hollyhocks and poppies. Then they must be propagated in some other way—by cuttings, grafts, or divided roots.

LESSION XIII.

CULTURE OF THE DAHLIA.

Facts for the teacher.— Dahlias are not difficult to grow. They require rich soil, but any ground which will grow good corn or potatoes, will with equal care in cultivation bring large returns of these flowers. There are four ways of propagation; by seeds, by tubers, by cuttings, and by grafting. The first two are most common.

Seeds planted in March in house or hotbed will yield blossoms as quickly as plants from tubers. Use rather deep flats and sow two inches apart in the row, transplanting when all danger of frost is past. The seed germinates in about a week.

Tubers are best started in boxes of moist, warm sand. Set a whole bunch together, just covering the crown. It is from the crown that new shoots start, and the bunch must be divided so that each "toe" has at least one bud, or it cannot grow; this can be done with much more certainty after the buds have started. Some tubers will have several shoots and others will have none. With these one may experiment with grafts and cuttings. For the first, take a thrifty shoot and cut its base wedge-shape; make a wedge-shaped hole in the top of a dormant tuber, insert the shoot and immediately plant them, packing the earth about them careful'y. Cuttings should be started in dishes of sand, kept warm and moist but not wet.

Dahlias are very thirsty plants, being so big and succulent, and should have plenty of water yet be well drained. Soot and ashes are good to dig into the soil about them. If too many buds appear, some should be pinched off for the sake of the greater size and beauty of those remaining.

When the blooming season is over, the tubers should be taken up on a warm sunny day and dried in the sun for a day or two. Then they should be stored in the dark, where it is cool and dry and out of the reach of rats and mice. Warmth and dampness will cause them to mold or rot.

References: "Lessons with Plants," Bailey; "The Flower Garden," Bennett.

PLANTING OF FALL BULBS

JOHN W. SPENCER.

Fall-planted bulbs are peculiarly adapted to children's gardens. When once the conditions of planting have been complied with, good results are almost certain to follow. This class of plants gives so much and asks so little that the harvest seems much like getting something for nothing. Very few weeds grow after the bulbs are planted in October, and only a few make much headway in April and May when the bulbs are at the height of their glory. If a farmer were as sure of an abundant return by merely planting the seed with no after cultivation, agriculture would be so simple and easy that the ignorant and the lazy could succeed.

In another chapter I have spoken of three grades of children's gardens viz.— the apprentice, the journeyman, and the master-gardener. Among the varieties of bulbs that I may hereafter mention, none will be too complicated in management for the apprentice grade to undertake, and at the coming of the robin and the bluebird in the spring, we all of us have such a flower hunger that even the modest snowdrops find appreciation.

There was a time when I thought that the pleasure of bulb-growing was for the rich alone. That was years ago when I saw these flowers only in the parks and on the lawns of the wealthy. That opinion was one of inference, which is not always the best foundation for opinions.

It is true, a paper of seeds of annuals cost but five cents and bulbs are a little more expensive, but the number of seeds that germinate and develop into productive plants is as uncertain as luck, and the seeds of annuals must be planted each season and the same risks incurred; whereas if a daffodil be planted it remains a perennial possession,— certainly it is a pleasure to me to care for those that mother planted many years ago which have increased in number year by year.

Why we plant a certain class of bulbs in the fall.

We call them fall bulbs because the fall months is the proper season for planting them. There is a large group of them.. Conditions necessary for their best development are peculiar as compared with bulbs that should be planted in the spring. Fall bulbs belong to the cold-loving class of plants.

Selection of bulbs for fall planting.

The question of the best way to order bulbs depends on the needs and money resources of the one making the order. A dollar and a quarter will not buy many bulbs, when "named" or rare varieties of hyacinths are chosen, but when the choice of variety or color is left to the seedsman, the sum will buy a hundred tulips. The reason that "mixed" lots in

Getting the ground ready for bulbs.

seed catalogs are cheaper than named varieties is not due to the fact that the bulbs are of a cheap or bargain-counter grade. The named varieties are sometimes new or rare, either of which reasons would account for a higher price. Every seedsman and nurseryman knows the vigilance necessary to keep varieties separate, and vigilance costs. To the novice it may seem a simple thing to do, but a little experience will lead him to think differently. The frequency with which he will find a black sheep in a white sheep's pen may cause him to suspect that varieties are capable of absconding from one plot to another. The average buyer of bulbs cares but little for varieties, but if he can secure certain colors he is satisfied. He will get much more for his money if he orders by color, leaving to the seedsman the choice of such varieties as have the colors desired.

Individual characteristics of fall bulbs.

The Snowdrop.— This is a simple flower and so modest that it would receive scant attention if its period of bloom came in competition with the gorgeous flowers of midsummer. It comes at a season when it has the monopoly of all the applause. Snowdrops may be planted in the sod of the lawn, where they make a good display when not hidden by late snows. With me they disappear after a season or two. For the small area of children's gardens, snowdrops should be massed by planting an inch apart in the rows, and sometimes two rows three inches apart. Such diminutive plants should be assembled in crowds rather than be scattered. They may be planted as a border or under shrubbery when the soil has good drainage. The picture shows a boy skinning away the sod under a barberry bush. He will next loosen the soil six inches deep before planting. The bulbs will have about finished their season's work before the barberry begins its growth and the latter cannot, therefore, monopolize the moisture, plant-food, or the sunshine. The price of snowdrop bulbs when sent by mail is about 20 cents per dozen or, a dollar per hundred. For depth see diagram.

The Crocus.— Close on the heels of the snowdrop comes the crocus, much larger in size and having a fair range in coloring. Like the snowdrop, the crocus may be planted in the lawn, but when so planted must be supplemented with new ones every second year. The first lawn

mowing of the spring must be deferred until the crocus has finished its period of bloom, long enough so that the leaves may have time to make food to be stored in the bulb to carry it through another spring. Otherwise the bulbs suffer from slow starvation. This is one reason why my lawn-planted bulbs disappear.

Liliputians that can be seen and not heard must get together in masses in order to gain attention. The same is true in planting crocuses. A common practice and a commendable one, is to marshall them on each side of a walk for inspection. If only a half dozen bulbs are at the command of the planter, put them in the area of a peck measure rather than scatter them over that of a bushel basket. Crocus bulbs have offspring which form on the top of the parent bulb and this will in time bring some of the succeeding generation to the surface. It, therefore, becomes necessary to replant the bulbs every third or fourth year. They should be about the same depth as the snowdrop. (See Diagram.) The usual price for " all colors mixed " is about 40c per hundred and 50c in named assorted colors.

Tulips.—These may be had in named varieties, assorted colors, and " all colors mixed." It is wise for those making their first planting of tulips to begin with " all colors mixed " which cost about 40c per dozen. They will give abundant pleasure and will be a fitting prelude to a more specific selection in the future which will probably be " by color " to be used in ribbon planting.

After several years' experience, I find that my taste is becoming specialized and when ordering I mention some particular strain in my list. In a way I had become acquainted with certain families and their behavior, and I now find a desire coming on me to make the acquaintance of individuals. I have observed that this development in floral taste to know the individual is common if not nearly universal.

The late varieties are usually at the height of their glory about the time of Decoration Day. Children, who as a rule are free givers, find much pleasure in making contributions for the occasion either to the Grand Army or to the graves of friends. Do not fail to include some of the late blooming tulips when making out your order.

Hyacinths.— Hyacinths are very beautiful, but the bulbs are expensive compared with the foregoing. When ordered in separate colors they are quoted at 75c per dozen. Yet to one who can afford them they are delightful and compensate for the expense. For depth and distance apart consult diagram.

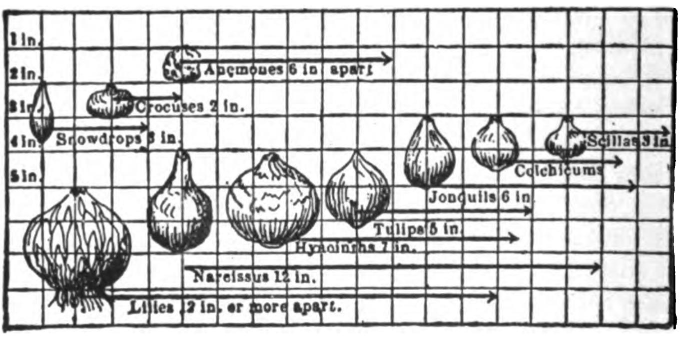
Single Narcissus.— The narcissus is a family with many relatives and all of good character. They are not so crotchety about exact conditions of the soil as is the case of the bulbs previously mentioned. Yet they will show the best results for the tender hand that works to make them

comfortable. The price for the single varieties are from $1.25 to $6.00 per hundred. "Mixed" are worth about one dollar and a quarter. Bulbs of narcissus increase rapidly and should an order for a hundred be divided into eight varieties, "seedsman's choice," the increase in a few years would be very satisfactory.

Scilla Siberica, Chionodoxa.— I have grouped these two bulbs together for when in blossom they remind me of little orphan children from a "Home" dressed about the same with perhaps a difference here and there in some small furbelow. They are most pleasing in color, being deep blue. If I could have but one, I would choose the scilla (or squill). If choice were denied, I could be consoled with the chionodoxa. They may be planted and treated in much the same way as the snowdrop and crocus. If planted beneath the shrubs they will be done blooming before the shrubs will be in leaf and overshadow them. When once planted and protected and fertilized as in directions for the care of tulips, etc., they remain permanent for a number of years. The prices of these bulbs in most catalogs are 30c per dozen or $2.00 per hundred for scillas, and 25c per dozen and $1.25 per hundred for chionodoxa.

How to plant fall bulbs.

My first word of direction must be a "don't" rather than a "do." Do not plant fall bulbs where standing water will damage them by causing rot. Good drainage is the first soil condition to be considered. Those who



Depth at which bulbs should be planted. From a catalog.

have seen Chinese lilies and Paper-white Narcissus growing in a dish of water with a handful of pebbles, or a hyacinth in a tall colored glass vase with the white roots hanging in the water, may conclude that water has no damaging effect on the same bulbs when planted in the soil. This idea, being one of inference, has no standing when compared with the facts. In affairs of life, do not infer more than you have to. In planting bulbs, the location of the bed is usually one of availability rather than one of choice, and you must accept conditions as you find them. Gravel, sand and the different loam soils give natural drainage. Clay soil does not.

Over-coming defective drainage.

In case of doubt as to natural drainage of soil, treat the plot as though it was defective in this respect. The picture shows a boy making an excavation preparatory to planting bulbs in a soil with defective drainage. The pit should be dug about two feet in depth. In the bottom put loose stones to the depth of about ten inches, and on top of the coarse stones put about four inches of gravel or stone of corresponding size, and on top of the gravel put two inches of sand. There now remain eight inches to be filled with soil in which the bulbs are to be planted. These dimensions are not arbitrary and may be modified to fit conditions. The office of the stone, gravel, and sand is to permit the drainage water to percolate down through the open spaces. If the soil in which the bulbs are to be planted should not be friable, some sand should be mixed with it.

If the teacher is not able to recognize a tenacious soil when she sees it, the pupils will no doubt be glad to make a test for her, particularly if they have not passed the mud-pie period of childhood. If they succeed in making marbles of the soil, sand should be added until the particles when moist lack cohesion. The pupils will think this test fun, and in it lies a lesson in soils that is fundamental, and one that the logarithm teacher should be glad to know. The story, "Adventures of the Soil," is as interesting as a romance and is made the theme of a separate chapter. Friability is an important factor in the make-up of a fertile soil. Where the area is small as is the case in children's gardens it is feasible to make a stiff clay friable by mixing with it sand or spading in rotted leaves, and thereby avoid a lumpy soil or one that forms a hard crust after drying.

Management of bulbs after planting.

Fall bulbs will give fairly good results in the first spring after planting even though the soil is poor. They have in them a store of starch prepared during previous seasons of prosperity which will carry them through one spring of poverty. To have them produce blossoms in successive springs without deterioration, abundant fertility is necessary and the foliage should remain until ripe.

Fall bulbs should have a winter overcoat. It should be put on when the ground begins to freeze. This usually occurs about the time of Thanksgiving. For that garment I much prefer coarse stable manure.

It should be applied ankle deep. This material will keep the bulbs from too severe cold; furthermore, the fall and spring rains and winter snows will soak the fertility out of the manure into the soil. This is a case of two birds and one stone — winter protection and plant food supply. It is better that fertilizer of any kind should not come in direct contact with the bulbs. If stable manure cannot be had, autumn leaves may be substituted to the depth of six to eight inches if the leaves are dry. The depth will be much less when wet. Put boards or stones on top of the leaves to keep them from blowing away. These may be removed later when the snows and rains have compacted the covering of leaves.

As soon as the bulbs show in the spring, the coarser part of the covering should be removed, leaving the finer parts to be worked into the soil later, much to its advantage in fertility.

What is best to do with bulbs after blooming.

In parks, where the idea is to keep the flower-beds a blaze of bloom from early spring until late fall, the bulbs of the crocus, tulip, and hyacinth are dug up, dried and laid away for replanting another fall. This gives an opportunity to replant the ground with summer plants which have been started in the green-house. This is done before the bulbs are through with their work of the season, that of developing starch which is later stored in the bulb. The supply is, therefore, curtailed and because of this curtailment there is a deterioration of vigor and in the course of three or four years the old bulbs have to be replaced by new ones.

I much prefer to let the leaves of all kinds of bulbs remain unmolested until, like autumn leaves, they give signs that their work for the season is ended. At this time I shave the surface of the bed, cutting off the now useless foliage and chickweed. I next sprinkle some chemical fertilizer over the bed and then with a garden rake I curry the soil as a hostler would the side of a horse. Nitrate of soda is one of the best chemical fertilizers for this particular purpose; but while shiploads of it come to this country from Chili, it is not easily obtainable in a small way. At most feed stores may be found cotton-seed meal which may be used instead. It is without odor which makes many kinds of fertilizers objectionable. Nitrate of soda dissolves like salt and the solution becomes immediately available for the use of the plant. Cotton-seed meal must first rot before the plant feels its help. When it becomes available its benefits continue longer than that of nitrate of soda.

Loosen the soil as deeply as possible and not disturb the bulbs. In this loose bed may be planted phlox, marigolds, zinnias, bachelor's buttons, asters, sweet alyssum, candytuft, nasturtiums, poppies, etc. With one exception — that of the poppy — the seeds of the flowers mentioned above may be sown in shallow boxes in April. The young plants will be growing while the flowers of the bulbs are finishing their career.

One may wonder why fall bulbs begin to develop foliage, and some like snowdrops and crocuses have flowers — the prelude to seeds — when the snow is in the air. All have closed their career of motherhood by Decoration Day. In comparison as to time many plants have just awakened to realize that winter is past. The condition of temperature during the month of April is such that there is no bacterial and chemical action in the soil to develop plant food, and sustain the activities that go on in a tulip or a hyacinth or a crocus at that time. The answer lies in the fact that in the bulb is a store of starch that sustains its growth. This growth is largely independent of plant food in the soil. It must, however, depend on the soil for the plant food to manufacture and store away food for use in the coming spring. Bulbs which have spent a winter in indoor blooming have become so depleted of starch that they cannot be used in pot culture again. They may, however, be planted in the open ground where a partial recovery will take place and the bulb will give an impaired bloom for a number of years after.

I have written the above with a picture before me of a group of boys and girls, who because of age or scant opportunity, have but little, perhaps no knowledge of plants and the pride of ownership of flowers, particularly those that have made their way by their individual efforts. For such children the simplest and straightest path to successful results must be chosen, and complications must be avoided as much as possible. For that purpose there is nothing better than the fall bulbs that I have mentioned. Some of the time in this picture there has been a teacher standing before the group. She was one of the heaven-born kind who can illuminate even the multiplication table. During some restless five minutes, she has stopped the routine of the school-room and taken a canvass of her pupil's knowledge of those flowers that bring cheer in the early spring. She was giving herself a rest by getting her pupils to talk about what they know of flowers and a lot of things they guess at, for with children guessing and imagining go for knowledge. I seemed to see hands fly up in the air, some clean, and some not so clean, with here and there an impatient jerk on the part of a child who had a burning thought which must be expressed for fear of a conflagration. This heaven-born teacher — God bless her — has thus inspired and instructed and started brewing a ferment of enthusiasm and ambition in the children to possess flowers "all their very own." I can understand the profound consideration on their part when they name their favorites.

I do not advocate donations in obtaining the bulbs for planting in such a school. Every one of these pupils should become good American citizens and learn to stand on their own feet and despise a beggar. If any friend to the cause wishes to give aid, let it be done in a way that the children may help themselves. This teacher of mine who can do many things that some crowned heads in pedagogy cannot do, will give best advice as to what bulbs the children had best choose to purchase with their pennies. She will also know best where the planting shall be done, whether on the school-grounds or at their homes. When conditions are equal, I prefer the home.

At times there was another woman in my picture. She was the wife of the village pastor and sometimes her husband has had charge of the Crossroads Church — the building that stands on a knoll bleak and bare and with horse sheds in the rear. She has the genius to make a cent carry the burden of a nic'

For a woman of this type I have admiration or veneration, and am glad to clasp her hand in good fellowship that I can never feel for some whose names may at some time appear in the Hall of Fame. She knows what it means to a child to show interest in what it may be doing. She tells the children that a crocus is no respecter of persons, and will do just as well for each of them as for the President of the United States. It is possible that she will tell these children that in the coming spring the church will want some of those tulips and narcissus and it may happen that the local paper may have an appreciative paragraph naming the donor.

It may come about that at some church sociable in the spring months this saint with an invisible halo and the heaven-born teacher will have an exhibit of the children's flowers, or perhaps the event may come off on some Friday afternoon at the school building, and the patrons of the school may be asked to be present with kind words for the good work done. The above picture gives the type of persons who hold my heart. They are self-reliant. They have a pride of character and a fortitude in braving untoward circumstances. They are not surfeited with the good things of life, and are able to make the most of small blessings.

UNCLE JOHN.

A semi-double dahlia.

Home Nature-Study Course

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By ANNA BOTSFORD COMSTOCK and JOHN W. SPENCER.

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The Raccoon.

ITHACA, NEW YORK
NEW YORK STATE COLLEGE OF
AGRICULTURE AT
CORNELL UNIVERSITY.

The earth is my home. Here I was born. I live on the soil, with the sky and wind, the drought and rain, the animals and plants, and the common scenes of the common day. My life will be poor and scant unless I know and love them all; and I should know first and best the things that are nearest by.

L. H. BAILEY.

The Editors wish to acknowledge the very efficient aid given by Miss Ada Georgia in preparing the lessons for the current year.

HOME NATURE-STUDY COURSE.

TEACHERS' LEAFLET.

USED ON THE WORK FOR THIRD YEAR PUPILS AS OUTLINED IN THE SYLLABUS OF NATURE STUDY AND AGRICULTURE ISSUED BY THE NEW YORK STATE EDUCATION DEPARTMENT.

THE TRILLIUMS OR WAKE ROBINS.

Preliminary work.—The trillium season is a long one; it begins in April with the Purple Wake Robin or Birth root, the trillium with purple, red or sometimes yellowish flowers. The season ends in June with the last of the great, white trilliums which flush pink instead of fading in old age. The children are always interested in these flowers; and when the first trilliums are brought to the school is the proper time for giving this lesson. The trilliums are particularly well adapted for planting in the shaded part of a garden. The editor many years ago planted some trilliums at the north side of her house and they have given flowers every year since.

Photo by Verne Morton

White butterfly hiding in blossom of the great white Wake Robin.

LESSON LXII.

THE STUDY OF A TRILLIUM PLANT.

Purpose.— To cultivate in the pupils the habit of giving careful observation to the appearance of a plant.

Observations.—

(1). What are the colors, shape and arrangement of the petals and sepals?

(2). Are they ruffled on their margins?

(3). Describe the pistil and stigmas.

(4). Describe the anthers and where they are placed in relation to the pistil?

(5). Does the flower stand upright or droop?

(6). How many leaves are there? How arranged?

(7). Draw a leaf showing its venation.

(8.) How far above the leaves does the flower stem extend?

(9). Describe the stem of the plant below the leaves giving length and color.

(10). What kind of a root has the trillium?

(11). What is the appearance of the rootlets?

(12). Does the trillium grow from seed each year or is it a perennial?

(13). Make a drawing of a trillium plant showing stem, leaves and flower.

Facts for teacher.— The color of the trillium flower depends upon the species studied. There are three petals, and the white and painted trilliums have the edges of the petals ruffled. The red and the nodding trilliums have petals and sepals nearly the same size but in the white trillium the sepals are narrow and shorter than the petals. The sepals are opposite the spaces between the petals so that when we look straight into the flower we see it as a six pointed star, three of the points being green sepals. The pistil of the trillium is six-lobed. It is dark red in the purple trillium and very large. In the white trillium it is pale green and smaller. It opens at the top with three flaring stigmas. There are six stamens with long anthers and they stand between the lobes of the pistil. There is a tendency for the flower to bend a little on its delicate stalk. There are three leaves which have a very interesting venation and make a good subject for careful drawing. The flower stem varies with different species and so does the length of the stem of the plant, the latter being fleshy and green toward the top and reddish toward the root. The trilliums have a very thick, fleshy and much scarred rootstock from which extend rootlets which are likely to be corrugated. The trillium is a perennial. Trilliums are so called from the word "Triplum" meaning three, as there are three leaves, three sepals and three petals.

LESSON LXIII.

THE HABITS OF THE TRILLIUM.

Purpose.— To call to the attention of the pupils the different kinds of trilliums and their habits.

There are four species of trilliums more or less common in New York State and they may be identied by the following table:

a. Flowers dark, reddish-purple with rank odor — Wake Robin or Birthroot.

b. Flowers with large, white petals which are one and one-half to two inches long — Large flowered Wake Robin or Wood Lily.

c. Petals, white striped with crimson—Painted Wake Robin.

d. Flowers white or pinkish with petals less than an inch long; the flower stem so bent that the little blossoms are often hidden below the leaves—The Noddingg Wake Robin.

Observations.—

(1). Where did you find the trillium or wake robin growing?

(2). Were there many growing in its vicinity?

(3). What insects visited the flowers and carried the pollen for the trillium?

(4). Do the same insects visit the purple and the white trilliums?

(5). What is the difference in odor between the purple and the white wake robins?

(6). Do the colors of the flowers change as the flower matures?

(7). What is the color and shape of the fruit of each different species of trillium, that you have studied?

(8). When is the fruit ripe?

Facts for teachers.— The trilliums grow mostly in damp, rich woods. The painted trillium is found in cold, damp woods along the banks of brooks; the white trillium is likely to be found in large numbers in a locality while the purple trillium is found only here and there. Flies and beetles fertilize the red trillium largely; they are attracted to it by its rank odor, which is very disagreeable to us but very agreeable to some insects. The large, white trillium is visited by bees and butterflies. The fruit of the trillium is a berry; the berry of the purple trillium is somewhat six-lobed and reddish; that of the large, white trillium is black and somewhat six sided and quite large. The nodding trillium develops a berry, which is reddish-purple while the berry of the painted trillium is bright red and shining and three sided. The berries ripen in late summer and early autumn.

References.—"Field Book of American Wild Flowers," Mathews; "Nature's Garden," Blanchan; "Child's Own Book of Spring Flowers," Comstock.

A white-faced maid, Wake-robin
  In a tiny, three-leaved hood,
Knows many of earth's secrets
  While nodding in the wood.
No longer is she sleeping,
  From magic spell she's free,
Her heart with wise lore laden
  Of the cabalistic Three.
This triple, ancient symbol
  The mystic, magic Three.

Laurance

TOADS AND FROGS.

Preliminary work.— No object will excite more interest in the pupils than a toad or frog in a little, moss garden. The moss garden may be made in a glass aquarium jar or on a plate with a wire screen about it; the essential part of the moss garden is that the moss be placed upon some dish that will not leak, so that it may always be kept wet. It should be deluged with water at least one a day, and should be placed out of the direct sunlight. In such a cage a toad or frog may be kept for weeks and its interesting ways be constantly under the observation of the pupils. The actions of a toad are surprisingly interesting; the editor smiles yet at the memory of the thoughtful way her pet toad rubbed and patted his stomach with his little hands after he had swallowed a June bug.

The teacher might begin the work by correcting the many false impressions about toads. Foremost of these is that handling a toad causes warts upon the hands; nothing could be more absurd than this notion. Another false idea is that toads are rained down; this probably had its origin in the fact that small toads, soon after they leave the water, hide in the crevices of the earth under stones and leaves or wherever dampness is found; and when the rain comes splashing down they all come out from hiding to enjoy the shower; toads especially enjoy having water sprinkled over them gently. Another fallacy is that toads are found alive in the bedrock of the quarries. The toad can go without food for a long time, but air and dampness are absolutely necessary to its life.

Another method of beginning the work is to study the eggs and tadpoles. Naturally the children will be interested in the toads which develop from their pet tadpoles; but wherever the teacher begins she will not fail to find the toad or frog an object of vital interest to the children.

LESSON LXIV.

THE EGGS OF FROGS AND TOADS.

Purpose.—To teach the pupils the differences between the eggs of frogs and toads, and to lead them to a careful observation of the development of the eggs into tadpoles.

Material.—Eggs of toads and frogs in an aquarium in the schoolroom. A common magnifying glass, which need not cost more than fifty cents; this latter is not absolutely necessary, but is a very desirable adjunct for the study of the eggs and tadpoles. The eggs may be found in almost any pond about the first of May.

Observations.—

(1). Where were the eggs found and at what date?

(2). Were they attached to anything in the water or were they floating free?

(3). Are the eggs in long strings or in masses of jelly-like substance?

(4). How can you tell the eggs of toads from those of frogs?

(5). Is the jelly-like substance clear or discolored?

(6). When the eggs are first laid are they round or elongated?

(7). Two or three days later what is their shape?

(8). Do the little tadpoles move while they are still in the jelly mass?

(9). How does the tadpole break from the jelly covering of the eggs?

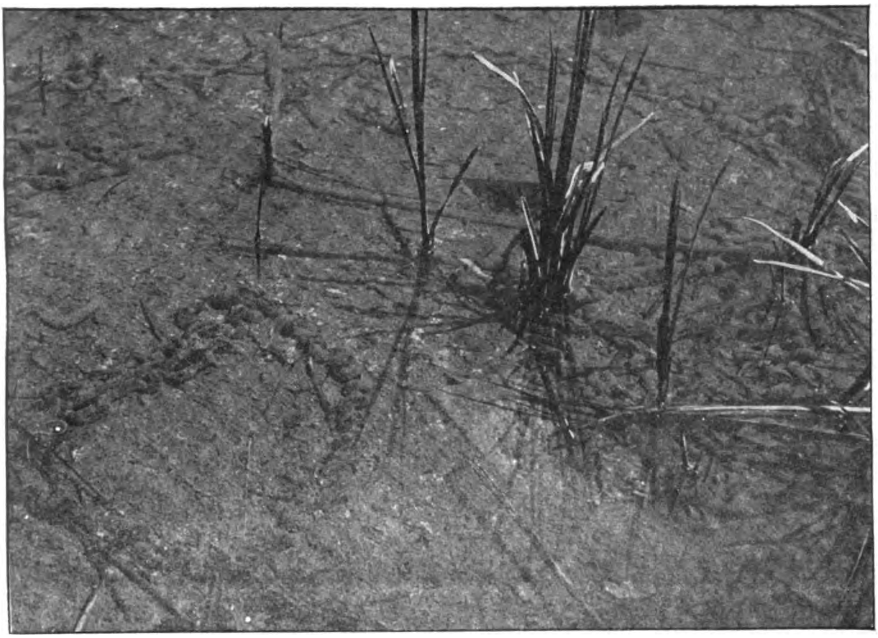


Photo by Verne Morton

Toads' eggs in shallow water.

Facts for teachers.— The eggs of toads and frogs are to be found in ponds either on the bottom or attached to some water weed during the months of May and June. If the season is early then the eggs will be found earlier. The eggs in the long strings of jelly-like substance are those of the toad, while those in the jelly-like masses are those of the frog, and are usually laid in deeper water than are those of the toad. When the eggs are first laid the jelly-like substance is clear and the eggs imbedded in it may be seen perfectly, but after a day or two bits of dirt accumulate on the jelly and the eggs become obscured. When the eggs are first laid they are quite spherical, but as they begin to develop they grow longer and finally a tadpole may be seen wriggling around in the jelly mass. In four or five days after the eggs are laid if the conditions are favorable the tadpoles will work out of the jelly mass which is their first food, and swim away in the water.

LESSON LXV.

THE TADPOLES.

Purpose.—To call the attention of the pupils to the very interesting development and habits of the tadpoles.

Material.— The tadpoles which have just hatched from the eggs.

Observations.—

(1). Can you distinguish which is the head and tail of the tadpole after it has just hatched and broken from the jelly?

(2). How does it act at first?

(3). How does it rest?

(4). Can you see with the aid of a lens some little fringes on each side of the neck? What are these?

(5). Can you see these fringes in the older tadpole?

(6). How does the tadpole breathe?

(7). How does the tail look and how is it used?

(8). Which legs appear first, and how do they look?

(9). Describe the hind legs of the tadpole and tell how they are used?

(10). How long after the hind legs appear before the front legs or arms appear?

(11). Where does the left arm come from?

(12). After both pairs of legs are developed what happens to the tail? Why is this?

(13). As the tadpole grows older how do its eyes change in appearance?

(14). As it grows to look like a toad how does it change in actions?

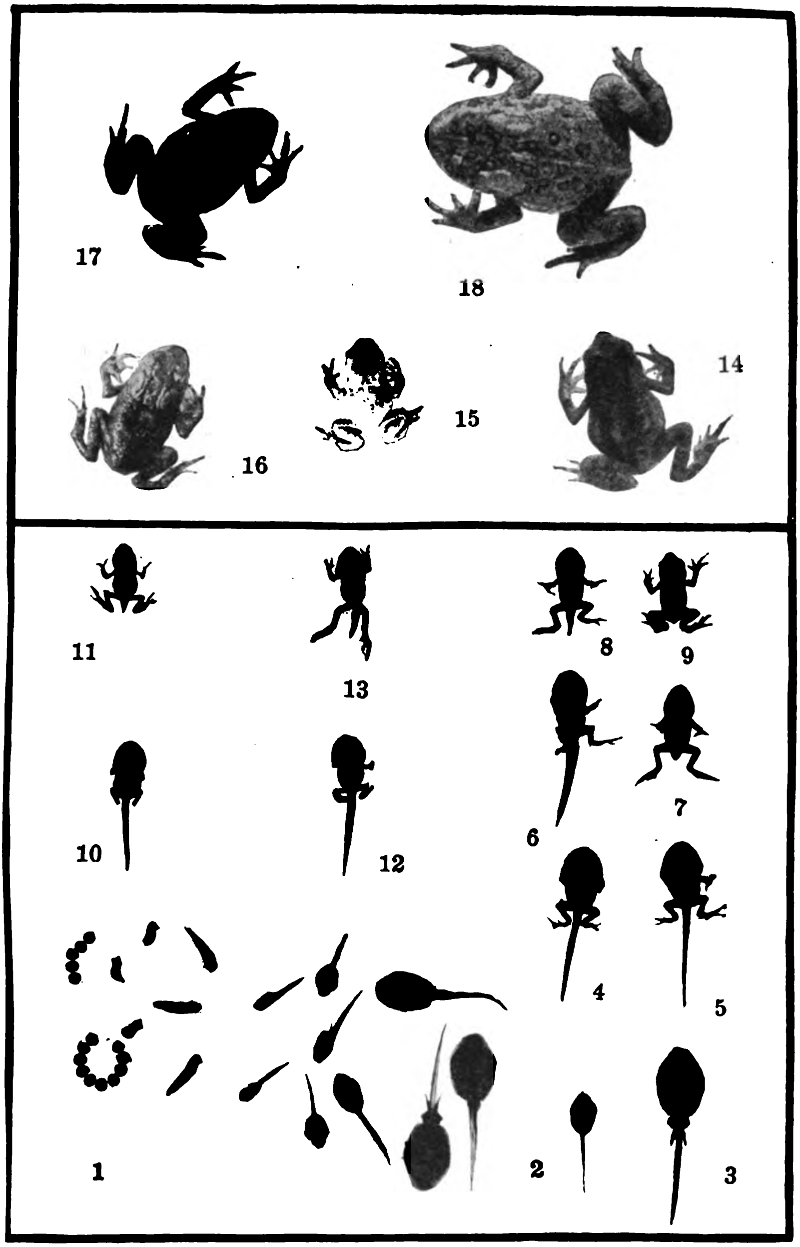
(15). Is there a difference between the hands and feet of the fully grown tadpole?

(16). If a tadpole's tail or leg is bitten off will it grow again?

(17). Does the tadpole when it is fully grown stay for a long time beneath the water? If not who not?

(18). Can you tell the difference between a toad tadpole and a frog tadpole?

Facts for teachers.—Although the pupils may not be able to distinguish the head from the tail when the tadpole first hatches unless it be looked at through a lens, the tadpole swims always head first, and the head end is the larger. At first the tiny tadpole has no mouth, but where we should expect the mouth to be is a V-shaped elevation, which is called the "sucker." From this sucker is secreted a sticky substance by means of which the tadpoles attach themselves to objects. At this stage they rest head up attached to water weeds. When two or three days old there may be seen with the aid of a lens a little tassel on either side the neck. These are the gills by which the little tadpole breathes. The blood passes through these gills and comes in contact with the air in the water and is thus purified. Ten days after they are hatched these gills disappear under a membrane which grows down over them, but the tadpole still breathes through gills which are situated at the sides of the throat. The water enters the nostrils and the mouth, passes through the opening in the throat and passes over the gills and out through a little opening at the left side of the body. In the larger tadpoles this breathing pore on the left side can be easily seen. When the arms develop the left arm is pushed out through this breathing pore. When about ten days old the tadpoles have developed small, round mouths, which are constantly in search of something to eat, and at the same time constantly opening and shutting to take in air for the gills. Their mouths have horny jaws for bitting off pieces of plants. The tail of the tadpole is long and flat surrounded by a fin and is the swimming organ. The children should especially observe the movement of its tail when the tadpole is swimming, and see how it helps in pushing the creature through the water. When the tadpole is a



Toad development in a single season (1903).

1-18. Changes and growth from April to November. *1-13. Development in 25 to 60 days.*
9-14. Different sizes, July 30, 1903. *15-18. Different sizes, October 21, 1903.*
10, 11. The same tadpole—11 is 47 hours older than 10.
12, 13. The same tadpole—13 is 47 hours older than 12.

month or two old, depending upon the species, its hind legs begin to show; they first appear as mere buds, but finally push out completely. The feet are long, have five toes, of which the fourth toe is the longest, and are webbed, so they may be used to help in swimming. Impress upon the pupils that wherever there is a web between the toes of animals or birds it means that foot is to be used in the water as a paddle. In about two weeks the arms begin to appear, the left one pushing out through the breathing pore. The "hands" have but four fingers and are not webbed. They are used in the water for balancing, while the hind legs are used for pushing. After both pairs of legs are developed the tail becomes smaller. There is a superstition that tadpoles eat their tails. This is true in a sense, because the material that is in the tail is absorbed into the growing body, but the children should understand that the tadpole does not bite off its own tail. If another tadpole or some other animal bites off the tail or leg of a tadpole not yet matured the tail or leg will grow again. At first tadpoles' eyes are even with the surface of the head, but as the tail is absorbed and the legs grow the eyes begin to bulge and grow more prominent, and look much more like toad's eyes. As the tadpole developes, its mouth grows larger and wider extending back under the eyes, and its actions are decidedly different than during its earlier life. It now comes often to the surface, and this is because the true air-breathing lungs are being developed, and the little creature is breathing the air of the atmosphere with its new lungs instead of the air in the water by means of the gills which have now disappeared. The most easily detected difference between the toad tadpole and the frog tadpole is that the former are usually black, while the latter may be colored otherwise. During the last week in June or the first of July, the children should be encouraged to visit the pond in which the tadpoles were found, for at this date the tiny toads are likely to emerge and there is nothing so funny as a tiny toad not larger than the end of a lead pencil hopping from the water with as much eagerness and vim as if it were fully grown.

LESSON LXVI.

A TADPOLE AQUARIUM.

Purpose.—To teach the children how to make the tadpoles comfortable and so be able to rear them.

Materials.—A tin or agate pan as large as a milk pan or a deep earthen wash bowl.

Things to be done.—

(1). Go to some pond where the tadpoles live.

(2). Take some of the small stones on the bottom and at the sides of the pond lifting them very gently so as not to disturb what is growing on their surface. Place these stones on the bottom of the pan, building up one side higher than the other, so that the water will be more shallow on one side than on the other; a stone or two should project above the water.

(3). Take some of the mud and leaves from the bottom of the pond, being careful not to disturb them and place upon the stones.

(4). Take some of the plants found growing under water in the pond and plant them among the stones.

(5). Carry the pan thus prepared back to the schoolhouse and place it where the sun will not shine directly upon it.

(6). Bring a pail of water from the pond and pour it very gently in at one side of the pan, so as not to disarrange the plants; fill the pan nearly to the brim.

(7). After the mud has settled and the water is perfectly clear, remove some of the tadpoles which have hatched in the glass aquarium and place in the pond. Not more than a dozen should be put in a pan of this size, as the amount of food and microscopic plants which are on the stones in the mud will afford food for only a few tadpoles.

(8). Every week add a little more mud from the bottom of the pond or another stone covered with slime, which is probably some plant growth. More water from the pond should be added to replace that which has evaporated.

(9). Care should be taken that the tadpole aquarium be kept where the sun will not shine directly upon it for any length of time, because if the water gets too warm the tadpoles will die.

LESSON XLVII.

THE TOAD.

Purpose.—To make the pupils observe closely the appearance of the toad, and to enable them to distinguish it from the frog.

Material.—A toad made comfortable in a moss garden.

Observations.—

(1). Describe the general color of the toad above and below.

(2). What is the texture of the skin above and below?

(3). Where was the toad found?

(4). Does it feel warm or cold to the hand? Is it slimy or dry?

(5). Is it a cold-blooded animal?

(6). Describe the eyes and explain how their situation is of special advantage to the toad?

(7). Note the shape and color of the pupil and iris. How does the toad wink?

(8). Find and describe the nostrils.

(9). Find and describe the ear.

(10). Note the swelling above and just back of the ear. Has this any use?

(11). What is the shape of the toad's mouth?

(12). Has it any teeth?

(13). Describe the arms and hands. How many fingers has the hand?

(14). In which way do the fingers point when the toad is sitting down?

(15). Describe the legs and feet. How many toes are there?

(16). What is the relative length of the toes and how are they connected?

(17). What is this web between the toes for?
(18). Will a toad change color if placed upon different colored objects?

Facts for teachers.—The general color of the common American toad is extremely variable. It many be yellowish-brown with spots and bands of a lighter color and the warts may be reddish or yellow. There are likely to be four irregular spots of dark color along each side of the middle of the back. The under parts are light colored and may be somewhat spotted. The throat of the male toad is black, the female is much brighter in color than is the male. The skin above is covered with warts which are glands; these glands secrete a substance which is disagreeable for the animal that tries to eat it. This is especially true of the glands in the large swelling behind and above the ear. Some people have an idea that the toad is slimy but this is not true; the skin is perfectly dry. It feels cold to the hand because it is a cold blooded animal, and this means an animal whose blood is about the temperature of the atmosphere surrounding the animal, while the blood of the warm blooded animal has a temperature of its own which it maintains whether the surrounding air is cold or not. The toads eyes are elevated and are very pretty. The pupil is oval and the iris which surrounds it is yellow, shining like gold. The toad winks in a very peculiar way. The eyes seem to be pulled down into the head during this process; the toad has the nictitating lid, which rises to cover the eye, similar to that found in birds. When a toad is sleeping its eyes are not bulging but are even with surface of head. The two nostrils are black and very easily seen; the ear is a flat, oval spot behind the eye and a little lower down. In the toad it is not quite so large as the eye. This is really the ear drum as the toad does not have an external ear like ours. The swelling or elongated wart above and back of the ear is called the paratoid gland; its chief interest to the children is that the glands which open on this wart give forth a milky substance when the toad is seized by an enemy, and the substance is poisonous. However, the snakes do not seem to mind it. The toad's mouth is wide and its jaws are horny. It does not need teeth in the ordinary sense since it swallows its prey whole. The arms are shorter than the legs and there are four fingers to each hand. When the toad is resting its fingers "toe in." The legs are long and strong, and the pupils should realize it is because of their length and strength that the toad is enabled to hop. There are five toes on the feet, the fourth toe is the longest and the hind feet are webbed to enable the toad to swim. However, this web is not as complete as that of the frog.

If a toad is removed from the earth or the moss garden and put in a white washbowl—in a few hours it will change to a lighter hue and vice versa. This is a part of its protective coloring to make it inconspicuous so snakes will not discover it.

LESSON LXVIII.

THE HABITS OF THE TOAD.

Purpose.—To make the pupils acquainted with the interesting habits and the economic value of the toad.

Observations.—

(1). Where does the toad live?
(2). How do its colors and warts aid it?
(3). When a toad is disturbed how does it act?
(4). How is it possible for a toad to make such long leaps?

(5). How does flattening out aid the toad?

(6). Describe the toad's tongue and tell where it is fastened to the mouth.

(7). How does the toad catch a fly?

(8). Does it swallow an earth worm head first or tail first?

(9). When trying to swallow an earth worm or large insect how does the toad use its hands?

(10). When it has a large mouthful how does it act when swallowing?

(11). Why is the toad of great use to the farmer?

(12). How does the toad drink?

(13). Where does it make its home?

(14). Where does it remain during the day?

(15). How does it make its burrow?

(16). Why does it come out at night?

(17). What happens to the toad in winter?

(18). What does it do in the spring?

(19). What sound does it make?

(20). How does its throat look when the toad is singing?

(21). Describe the action of the throat while breathing.

(22). What are the toad's enemies?

(23). How does it escape or defend itself from its enemies?

(24). How and why does the toad shed its skin?

Facts for teachers.— The toad prefers a cold, damp place in which to live. This is likely to be under sidewalks or boards or piazzas, and the warty upper surface and its brown color make it resemble very much the surrounding earth and in this way protect it from observation. When the toad is disturbed it will hop off, taking long leaps and act frightened, but if very frightened it will flatten out on the ground. When thus flattened out it looks so nearly like a clod of earth that it is almost hidden from the keenest eyes. If seized by the enemy it will sometimes "play possum" and act as if it were dead, but when actually in the mouth of the enemy it will give a most terrific and heart-rending cry. The toad's tongue is attached to the lower jaw at the front edge of the mouth. This tongue can be thrust far out from the mouth, and it has a sticky substance on it to which the insect if touched must adhere and then is drawn back into the mouth and swallowed. It should be noted that while the tadpole eats vegetable matter, as soon as the toad is fully developed it lives entirely upon small animals, usually insects. It eats almost any kind of an insect and lives very largely upon those which are injurious to the grass and to plants. The toad is really the best friend of the gardener and the farmer, but has been most ungatefully treated by those whom it has befriended. When a toad attempts to swallow an earth worm it will walk around the squirming creature until it can seize it by the head. The probable reason for this is that the horny hooks extending backward from the segments of the worm are not pleasant when they rasp the toad's throat. If the toad has a large mouthful it will use its hands to help in stuffing it down the throat; this is a very comical sight. When swallowing a large mouthful it closes its eyes as if this aided in the process. The toad never drinks by taking in water through the mouth, but absorbs water through the skin. When a toad wishes to drink it will stretch out in shallow water and in that way satisfy its thirst. A toad will waste away and die in a very short time

if kept in a dry atmosphere. The toad makes its home by burrowing in the earth. It has a peculiar method of kicking its way backward into the earth until nothing but its head shows. Then if an enemy comes along, back goes the head, the earth caves in around it and no toad is to be seen. It remains in its burrow or in its hiding place usually during the day and comes out at night to feed. This may be an advantage because the snakes are then asleep, and the snake is its most feared enemy; and too, there are many insects that are out at night. Perhaps the best place to find toads is in the vicinity of the street lights where they gather in numbers to catch the insects which swarm there. In winter the toad buries itself deeply in the ground and goes to sleep remaining in this dormant state until the warmth of spring wakes it up, and then it comes out and goes back to its native pond, there to lay the eggs for the coming generation. The song of the toad is a pleasing, crooning sound, a sort of a gutteral trill. When singing the throat of the toad is puffed out; this extension of the throat is called a vocal sac. It is filled with air which is drawn in through the mouth and it acts as a resonator. The sound is caused by the passing of air through the vocal cords in the throat; the air is drawn in at the nostrils and is passed back and forth from the lungs to the mouth over the vocal cords. While breathing we can see the throat move in and out. This is caused by the movement made in swallowing the air and forcing it into the lungs. The toad has no ribs by which it can inflate the chest, and in that way draw air into the lungs as we do. It is, therefore, obliged to force the air into the lungs by swallowing it. The toad has many enemies; chief among these is the snake; crows also and other birds prey on toads. As the toad grows it sheds its horny skin, which it swallows; however, this shedding of the skin is usually done in private, and the ordinary observer sees the process but seldom. The toad enjoys very much having its back scratched gently.

LESSON LXIX.

THE FROG.

Purpose.—To call attention to the appearance and habits of the frog.

Material.—A frog in an aquarium in which there is a stick or stone projecting above the water. Any species of frog will do but the common spotted or leopard frog is a particularly attractive object for study. So also is the common green frog.

Observations.—

(1). Where was the frog found?
(2). Where does it live?
(3). When found on land how does it seek safety?
(4). Compare the form of a frog with that of a toad.
(5). Describe the skin, its color and texture.
(6). Compare the skin of the two.
(7). Compare the colors of the two above and below.
(8). Describe the colors and markings of the frog.
(9). Describe the eye, ear, nostrils and mouth.
(10). Compare the hands and feet of the frog with those of the toad.
(11). Why the differences in the feet?
(12). What is the feeling to your hand when you put it on a frog?
(13). How does the slipperiness of the frog help it?

(14). On what does the frog feed?
(15). What sound does it make?
(16). Where are the sound sacs of the frog?
(17). What are the frog's enemies?
(18). How does it escape from them?
(19). How does it swim?
(20). The two being equal in size which can leap the farthest the frog or the toad and why?
(21). What happens to the frog in winter?

Facts for teachers.—The frog is usually found in the pond or on its borders; however, the leopard frog and some others are sometimes wanderers and may be found some distance from the pond. It spends most of its life in or about the water, and if caught on land takes great leaps to reach its native pond. The frog is more slim than the toad; it is not covered with such great warts, and it is very cold and slippery to the touch. The frog is likely to be much more brightly colored than the toad, having much of yellow and green in our common species. The eyes are very prominent. The ear in bullfrogs is larger than the eye; the bullfrog has horny teeth, which are very tiny and are used for biting off food and not for chewing. The hands and feet of the frog are similar to those of the toad except that the hind feet are more completely webbed, and the hind legs are larger and stronger in proportion. The food of the frog is largely the insects which frequent damp places or the water. The bullfrog finds all of its food in the water. The sound sacs of the frog instead of being under the throat, as in the toads and tree frogs, are at the sides of the throat and may be seen when inflated back of the eyes often extending out over the front legs. In addition to the snakes the frogs have inveterate enemies in the herons, which walk about in shallow water and eat them in great numbers. The frog's only hope of escaping its enemies is through the slipperiness of the body, or its long, quick leaps. As a jumper the frog is much more powerful than the toad because the hind legs are of greater development in comparison to the size of the animal. Frogs hibernate in mud in and about ponds during the winter. The frog is an interesting creature; its colors are harmonious and pleasing and its eyes are really beautiful.

THE TREE FROG OR TREE TOAD.

Preliminary work.—Associated with the first songs of the robin and blue bird is the equally delightful chorus of the spring peepers; yet how few of us have ever seen one of these choristers! Should we find one it would prove to be the tiniest froglet of them all, for the spring peeper or Pickering's Hyla is a little more than an inch in length when fully grown. One of these tree frogs kept in a moss garden made in a glass aquarium jar is a never-ending source of delight to the children. We have several other tree frogs which trill above our heads, and their song is often mistaken for that of the Cicada, which is really quite different and far more shrill. The tree frog's note is particularly winning and confidential, but the singer is exceedingly hard to find. In fact, tree frogs are so well protected by their color that they are seldom discovered except by chance. The only way the editor ever succeeded in getting a tree frog was when she went hunting for them on the margin of a marshy pond at night with the aid of a lantern. The spring peepers do not seem to be afraid of the light, and may thus be captured if the hunter is sufficiently enterprising. However, this lesson on the tree frog should not be given unless a specimen is at hand for the children to study.

LESSON LXX.

THE TREE FROG.

Purpose.—To make the pupils acquainted with the appearance and habits of this interesting little creature.

Material.—A tree frog in a moss garden in an aquarium in which a thick twig may be placed in an upright position.

Observations.—

(1). What are the chief differences between the tree frog and other frogs?

(2). How does the tree frog climb?

(3). How does it manage to make the discs on its toes cling and then let go?

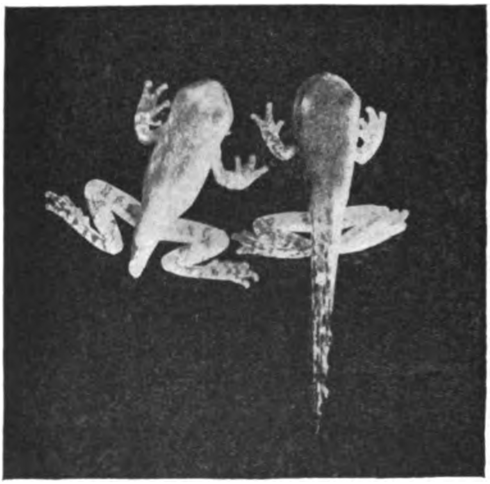
(4). Will it remain voluntarily head down?

(5). How does it look when peeping?

(6). What do tree frogs eat?

(7). Where do they live?

(8). How do the eggs of the tree frog look?



Tree frog tadpoles.

(9). How do the tree frog-tadpoles look?

(10). Of what use are the tree frogs to us?

Facts for teachers.— The tree frog is much smaller than the other frogs, and its toes and fingers are provided at the ends with round discs, by means of which they can cling to a smooth surface. These discs do not act as suckers as so many people think; but a sticky substance is secreted on their lower surface, and it is by the means of this the tree frog clings.

The tree frog on a vertical surface will not willingly remain head downward, but will always turn about so that the head is directed upward. When it is peeping the vocal sac under the throat swells out until it is almost globular. The tree frogs live upon insects, almost any insect of proper size that comes near them. They live in trees or on shrubs or vines; in fact, they live almost any place where they can hide under leaves and find plenty of insects. The eggs of the spring peeper are laid in ponds during April; each egg has its one little globe of jelly about it and is fastened singly to water plants. The tadpoles are small and delicate. The under side of the body is reddish and shines with metallic lustre. They differ from other tadpoles in that they often leave the water while the tail is still quite long. In June they may be found among the leaves and moss on the banks of ponds. They are indefatigable in hunting for gnats and mosquitoes and ants. Their destruction of mosquitoes as pollywogs and adult frogs renders them of great use to mankind.

References for toads, frogs and tree toads.—Cornell Nature-Study Volume, "The Life History of the Toad," by S. H. Gage; "The Frog Book," Dickerson; "Familiar Life in Field and Forest," Mathews; "American Natural History," Hornaday; "Elementary Zoology," V. L. Kellogg.

HOW TO MAKE AN AQUARIUM.

Purpose.—To teach the pupils to make an aquarium from simple materials at hand.

Materials.—It is a mistake to think that an aquarium must be an expense affair. Almost any glass receptacle will do, glass being chosen because of its transparency, so that the life in the aquarium may be observed. Tumblers, jelly tumblers, fruit jars, butter jars, candy jars and battery jars are all available for aquaria. The tumblers are especially recommended where you wish to observe the habits of some aquatic insect

(1). Place in the jar a layer of sand about an inch or more in depth.

(2). In this sand plant the water plants which you find growing under water in a pond or stream; the plants most available are Water-weed, Bladderwort, Water Starwort, Watercress, Stoneworts, Frog-spittle or Water-silk, and a few plants of Duck Weed.

(3). Place on top a layer of small stones or gravel; this is to hold the plants in place.

(4). Tip the jar a little and pour in very gently at one side water taken from a pond or stream, or rain water. Fill the jar within two or three inches of the top; if it be a jelly tumbler fill to within an inch of the top.

An aquarium.

(5). Let it settle.

(6). Place it in a window which does not get too direct sunlight. A north window is the best place; if there is no north window to the schoolroom place it far enough at one side of some other window so that it will not receive too much sunlight.

(7). To get living creatures for the aquarium use a dip net, which is made like a shallow insect net.

(8). Dip deep into the edges of the pond and be sure to bring up some of the leaves and mud, for it is in these that the little water animals live.

(9). As fast as dipped up these should be placed in a pail, so that they may be carried to the schoolroom.

(10). In introducing the water animals into the aquarium it is well to put but a few in each jar.

The care of the aquarium.— Care should be taken to preserve the plant-life in the aquarium, as the plants are necessary to the life of the animals. They not only supply the food, but they give off oxygen which the animals need for breathing, and they also take up from the water the poisonous carbonic acid gas given off from the bodies of the animals.

(11). The aquarium should be kept where there is a free circulation of air.

(12). If necessary to cover the aquarium to prevent the insects, like the water boatman and water beetles from escaping, tie over it a bit of mosquito netting, or lay upon the top a little square of wire netting used for window screens.

(13). The temperature should be kept rather cool; it is better that the water of the aquarium should not be warmer than 50° Fahrenheit, but this is not always possible in the schoolroom.

(14). If any insects or animals die in the aquarium they should be removed at once, as the decomposing bodies render the water foul.

(15). To feed the animals that live upon other animals take a bit of raw beef, tie a string to it and drop it in, leaving the free end of the string outside of the jar. After it has been in one day, pull it out, for if it remains longer it will make the water foul.

(16). As the water evaporates it should be replaced with water from the pond.

References.—Cornell Nature-Study Volume, "Life in an Aquarium"; "Insect Life," Comstock; "The Brook Book," Miller; "Nature-Study and Life," Hodge.

THE STRAWBERRY.

***Preliminary** work.*—Give some history of the common garden strawberry, which was taken from Chili to Europe nearly a hundred years ago, and from thence imported to America, although it is native to the western mountain regions of both North and South America. It has been so improved by cultivation and crossing with other species that it is a much more prolific and useful plant than its wild progenitor.

Ask pupils to note such differences as they are able to discover between the cultivated and wild strawberry. Nearly everyone knows the fruit in its season, but few, even of those who cultivate it, know what an interesting plant it really is.

Photo by Verne Morton

The wild strawberry.

LESSON LXXI.

THE PLANT.

Purpose.—To quicken the pupil's observation as to how the plant grows, sustains and propagates itself.

Material.—A strawberry plant with roots and runners attached, for the observation of the class; for each pupil a leaf, so carefully removed from the plant as to show its clasping sheath and stipules. These may readily be found, even in early spring, for the strawberry retains its green crown the seasons' round. The best roots and leaves for study will be found on a young plant, the first on a runner to take root.

Observations by pupils.—

(1). What kind of root has the plant; that is, has it a single tap-root, or is it branching or fibrous?

(2). What color is the root? Do you notice any difference in color between the roots of the young plants on the runners and those of the parent plant which grew the previous season?

(3). Has the plant a stem?

(4). How are the leaves arranged; that is, are they in a circle or whorl, or one above another, rising to an apex?

(5). Describe the base of the leaf and the way it is attached to the plant.

(6). Is the petiole or leaf-stem round or angular, solid or hollow, smooth or hairy?

(7). Has each leaflet a pedicel or stem of its own, or does it grow directly from the main stem? What is the number of the leaflets? What is their general shape? Draw a leaf as well as you can.

(8). Describe the edges of the leaflets. Are they toothed all the way round?

(9). Describe the veins and leaf surfaces. Are the leaves alike in color on both sides?

(10). From what part of the plant do the "runners" spring?

(11). When do the runners begin to grow?

(12). Does the runners strike root before forming a new plant or does the little plant grow on the runner and draw sustenance from the parent plant?

(13). What happens to the runners after the new plants have established themselves?

(14). Does the parent plant survive or die when the family of young plants is established?

Facts for teachers.—The root of the strawberry is fibrous and thread-like. When growers want plants for setting new strawberry beds, they are careful to take only such as have light colored and fresh-looking roots. On old plants the roots are hard, black and woody, and such are undesirable for planting, having been exhausted by the maturing of at least one crop of fruit and the putting forth of runners.

The stem of the plant is partly underground and so short as to be unnoticeable. However, the leaves grow alternately, one above another, so that the crown rises as it grows. The base of each leaf has a broad, clasping sheath which partly encircles the plant and extends upward in a pair of ear-like stipules. The leaf-stem when young is round, soft, and thickly covered with fine hairs, but as it lengthens and grows older it flattens a little and when mature develops a slight groove on the upper side. Each leaflet is a reversed oval in shape, deeply toothed on sides and large end, but entire when forming the pointed base. They are three in number and each has a tiny stem or pedicel of its own. The veins are light colored, very prominent on the lower side but forming depressions on the upper surface, which is a much darker green than the under side of the leaf.

The runners begin to grow after fruiting has ceased and spring from the outer part of the crown. They are strong and fibrous and hairy when young. Some are short "between joints," others seem to reach far out as if seeking for

the very best location before striking root. The young plant will often have several leaves before putting forth roots. After the young plant has root growth enough to feed itself, the runner ceases to carry sap from the main stem and withers to a mere dry fiber. The parent plant continues to live and bear fruit, for the strawberry is a perennial, but the later crops are of less value.

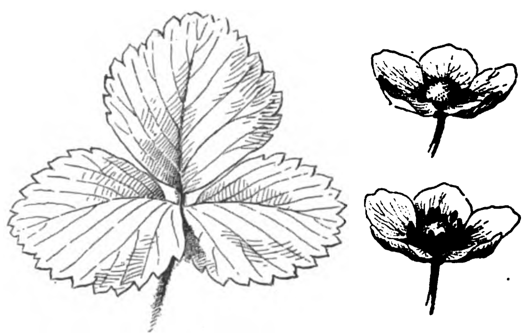
Growers either renew their plots each year, or if intending to harvest a second year's crop, cut off all runners as they form.

LESSON LXXII.

THE FLOWER.

Purpose.—To teach the children the parts of the flower and help them to distinguish the perfect-flowered and pistillate varieties.

Material.—Blossoms of both pistillate and perfect-flowered varieties, and if obtainable, a wild strawberry plant. The better plan would be to pot a plant of each variety and place it in a sunny window. Warmth and moisture will force them into bloom in a short time, so that flowers may be had for study before they are in blossom out-of-doors, giving an opportunity for verification and review.



Strawberry leaf; pistillate flower above and staminate flower below.

Observations by pupils.—

(1). What is the color of the blossoms?

(2). Count the parts in the "hull" or calyx.

(3). Note the number of petals. Does the number differ in different flowers? Has the wild strawberry as many petals as the cultivated ones?

(4). Study (with a lens if possible), the small green "button" in the center of the imperfect flower. This is made up of pistils so closely set that only the very tips or stigmas are visible.

(5). Where are the stamens set in the perfect flowers? Are they many or few? Do the wild strawberry blossoms lack stamens?

(6). How are the blossoms arranged in the cluster, in a spike or a loose panicle?

(7). Do the flowers all open at the same time?

(8). Do the blossom-stems rise above the leaves or are they somewhat sheltered and hidden by them?

(9). What parts of the blossom fall away and what parts remain when the fruit begins to form?

Facts for teachers.—If comparison of the wild and cultivated sorts is practicable, show the pupils that the strawberry in its wild or natural state has always five white petals set on short claws within a calyx made up of five, pointed, green sepals, outside of which is another row of five, leafy green bracts. Much tillage and excess of food has caused a tendency to "double" in the cultivated ones, and though many blossoms have the usual number of petals, others may have seven or eight. The writer found one flower this past summer which had twelve petals. Also the wild flowers are usually "perfect," that is, the central, green button with its many pistils is always surrounded by a fringe of many, slender filaments, each tipped with a golden anther pollen-box. But in many cultivated varieties the pollen and the pistils are borne on different flowers. Teach the children that it is necessary that some of the dust or pollen from the stamens should fall on the stigmatic surfaces of the "imperfect" flowers to enable them to bear fruit, so that in planting, about one plant in five should be staminate. Bees will carry the pollen. Growers think that pistillate varieties resist frost a little better than the others, besides being very prolific.

The blossom-stem of the strawberry is round, smooth, and quite strong, holding its branching panicle of flowers erect, though later the heavy fruit weighs it down; it is usually shorter than the leaf-stems among which it nestles. The flowers open in a series, so that ripe and green fruit, flowers and buds may often be plucked on the same stem. Only the petals and stamens wither and fall away, the green calyx remaining as the "hull" which holds the green central knob full of pistils which swell and ripen into the juicy fruit.

LESSON LXXIII.

THE FRUIT.

Purpose.—To help the children to see for themselves what is the real fruit or seed of the plant.

Material.—One of the fruits on the desk of each child, if possible. A hand lens is most desirable for this lesson, and a very serviceable one may be bought for fifty cents.

Observations by pupils.—

(1). Are the fruits all of the same shape and color?

(2). Is the pulp of the same color within as on the surface?

(3). Has the fruit an outer coat or skin?

(4). What are the specks on its surface?

(5). With a pin point remove one of the tiny pits or seeds. What is its shape? If possible open one of the little shells, look at it with a lens and describe what you see.

Facts for teachers.—To the botanist the strawberry is not a "berry," that definition being limited to fruits having a juicy pulp containing many seeds and surrounded by a skin or pericarp, like the currant, grape and tomato, while the strawberry is a fleshy receptacle, acidly sweet in taste, bearing seed in shallow pits on its surface. These seeds are so small that they are not noticed when eating the fruit, but each one is a tiny nut or akene, almond-shaped, and containing within its tough, little shell a starchy meat for the sustenance of the future plant which it enfolds. It is by planting these seeds that growers obtain new varieties. About three years are needed to bring such plants into bearing, and

among many hundreds there may be but one or two worthy of cultivation. Varieties show their difference in color and shape, just as do their wild relatives. The Virginian or wild, meadow strawberry is, when well shaped, nearly spherical and its color is bright scarlet, while the wood strawberry is long and cone-shaped, and so light a red as to be almost pink. Some cultivated varieties have white centers or tips and are very irregular in shape.

LESSON LXXIV.

ENEMIES OF THE STRAWBERRY.

Purpose.—To teach the pupils to recognize and to combat the enemies of the strawberry.

The White Grub.—If the strawberry patch has been set on land which has been in sod it may be troubled with the white grub, which is the larva of the large, brown beetle known as "June bug." This larva lives for three years in the soil, feeding on the roots of plants. If sod land must be used for the strawberry bed, it should be ploughed and thoroughly pulverized in the fall, thus killing many of the grubs, pupae and recently-formed beetles; also the ground should be well stirred again before and after setting the plants in spring or summer, for thorough cultivation is the best means of fighting this insect. Affected plants look wilted and sickly, and are readily distinguished. In small plots it is practicable to watch for and dig out the culprits as their presence is there noted and it pays to do so.

The Strawberry Weevil.—This is a mere speck of a snout-beetle only a tenth of an inch long, but it does many dollars worth of damage. Just before the bud is ready to open, the mother pierces through the closed petals and lays an egg among the clustered pollen-boxes, for she chooses only the perfect flowers, and the larva when hatched feeds on the pollen. Then she punctures the stem just back of the calyx, causing it to wither and the bud drops off. It is so tiny an insect that usually the first indication of its presence is the dropping buds. Lime sprayed on the plants acts as a deterrent to the egg deposition, driving the mother to other plants, whose pollen it likes, among which are wild bergamont and the red-bud tree. Arsenical poison used just while the buds are forming is also a preventive.

DISEASES.

Leaf-spot, Rust or Blight.—This is the worst of the diseases of the strawberry. It may appear at any time during the season, but most often comes just after the fruitage. Little red, black-bordered spots are seen upon the leaves, calyx and stems of the plants, becoming brown and purple-edged as they enlarge and run together. Heat and moisture help its spread. In the fall, small, black specks appear in the dry, ash-colored center of the spots. These are the "resting-spores" and carry the disease over to the next season. Remedies should be preventive, spraying with Bordeaux mixture before the blossoms open and after the fruit is picked. Mowing and burning the leaves should be practiced if spraying has been neglected.

Powdery Mildew.—This usually comes in damp weather. It attacks all parts of the plants. The leaves curl up like a cup, as though suffering for water, while a white, cobwebby powder appears on the surface. Early spraying with Bordeaux mixture is the remedy.

THE BLACK BIRDS.

Preliminary work.— As the black birds are among our earliest visitors in the spring and as they come in flocks and beset our leafless trees like punctuation marks and squeak like musical wheelbarrows, they naturally attract much attention. What they are, where they came from, where they are going, and what they are going to do are the questions which naturally interest the pupils. This lesson should be given when there are plenty of black birds to observe.

LESSON LXXV.

THE BLACK BIRDS.

Purpose.—To teach the pupils to distinguish the species of black birds and note closely their habits.

Observations.—

Cowbirds.

(1). What is the date when the black birds first appear in the spring?

(2). Do they appear in flocks?

(3). How large is the black bird compared with the robin?

(4). What is the color of the head, neck and breast?

(5). What is the color of back, wings and tail?

(6). Is there any red or yellow on the wings?

(7). What is its song?

(8). How does it act while singing?

(9). Describe the use of the tail in flight.

(10). What is the color of the eye?

(11). When on the ground what is the black bird doing?

(12). Does it run like the robin, or hop or walk?

(13). Are there in the flock some birds which are lighter or duller in color than the others?

Facts for teachers.—All the black birds have the habit of walking while on the ground. The males also have the habit of spreading the wings and tail a little when they give their song. The female cow bird and red winged black bird are not black, but may be identified by the association with the black males in flocks. The tail of black birds is long and is used very obviously as a steering organ during flight. We have in New York State four species of black birds more or less common. These are the Grackles, the Rusty Black Bird, the Cow Bird and the Red-winged Black Bird. They may be identified by the following table:

A. Birds larger than the robin.

b. Back, head, neck iridescent showing bronze-purple, green and blue; eye bright yellow—Male grackle.

bb. Back bluish-black with no metallic reflections—Female grackle.

AA. Birds a little smaller than the robin. Plumage mostly black.

b. Plumage bluish-black the feathers tipped with brownish or yellowish, very glossy. Eyes pale yellow. Seen in New York State during spring and fall migrations—Rusty Blackbird.

bb. Plumage black with red and buff epaulets—Male Redwing.

bbb. Plumage black except head and neck which are coffee color —Male Cowbird.

AAA. Birds smaller than robin with plumage grayish-brown above.

b. Under parts grayish—Female Cowbird.

bb. Underparts streaked with black and white. Shoulders reddish—Female Redwing.

The Grackles or Crow Black Birds.— There are two varieties of these in New York State, the Purple and the Bronze Grackle, but it needs an expert to tell them apart and such distinctions belong rather to ornithology rather than to nature-study. The grackles are from two to three inches longer than the robin, measuring in length twelve to thirteen and one-half inches. The males have the head, neck, throat and upper breast iridescent showing purple-green and blue metallic colors. The wings and the tail are purplish or bluish-black. The females are duller with back and under parts brownish and with less of the metallic colors about the head and neck. The tail is long and wedged shape when spread, the middle feathers being much longer than those at the side. The grackles come in flocks early in the spring, sometimes appearing the last of February. They continue together while nesting. They build large, bulky nests made from coarse grass and twigs and prefer evergreen trees for their nesting sites. The eggs are blue or greenish marked with brown. The grackles may often be seen walking sedately on the ground, hunting for bugs, beetles, grubs and the like.

The Red-winged Black Bird.— This favorite may be easily distinguished from the other black birds because of the bright red epaulets marked with buff, which decorate the wings of the male. The female is streaked brown above and streaked buff below with a yellow tinge at the throat. These birds are always found about marshes. The male spreads his beautiful wings to show his epaulets as he sings his liquid and delightful "Oh-ka-lee" or "Kong-quer-ree." The males arrive three weeks before the females in the spring. The nest is made of grasses and stalks of weeds lined with finer moss or roots and is placed in a low bush or attached to reeds. The eggs are pale blue streaked and spotted with purple or black. Seven-eighths of the food of the bird consists of weed seeds and injurious insects.

The Rusty Black Bird.— This is not as large as the robin; its plumage is entirely bluish-black, the female being slate colored above and lighter below. The tail feathers are nearly equal length and the tail is not, therefore, wedge-shaped. like that of the grackle. The rusty black bird appears in small flocks from March to May and again in September and October, usually haunting the marshes and wet meadows. They nest from New Brunswick to Labrador. This species can be distinguished from the grackle by its lack of iridescent colors and smaller size, and from the red-wing by the lack of epaulets on the male and from the cow bird by its black color. It has a musical note.

The Cow Bird.—This lazy rascal usually appears in small flocks, haunting pastures where there are cattle and also striding about lawns and meadows. The male has head, neck and breast coffee color, the rest of the plumage being black. The female is brownish-gray. The ordinary note is a long, squeak followed by two short notes. When in flocks they also chatter noisily. The cow birds are unpleasant to look upon and to hear, for their true character as parasites seems to show in their demeanor. The mother cow bird is a thief of the worst type, since she steals for the young the attention and affection of the mothers of other young birds. She lays her egg in the nest of some other bird and the big nestling as soon as hatched either gets all the food thus starving the rightful nestlings or smothers them. A list of ninety-one species has been given in whose nests cow bird eggs have been found. Not the least of the unconscious sins of the English sparrow is that it raises so many cow birds to prey upon our useful song birds. The brown head and neck distinguish the cow bird from the other black birds.

LESSON LXXVI.

THE HABITS OF BLACKBIRDS.

Purpose.—To make the pupils acquainted with the different species of black birds and their habits.

Photo by Verne Morton

Egg of cowbird in nest of field sparrow.

This lesson should be in the form of a written or oral exercise in English and may embody the results of reading or observation. The following topics are suggested:

(1). Cow birds, their migrations and nesting habits.

(2). The red-wing black birds, how and where they build their nests?

(3). The story of a cow bird.

(4). An account of relatives of black birds.

(5). Are the black birds beneficial to the farmer and fruit-grower?

References for 1, 2, 3 and 4 are: "Bird Neighbors," Blanchan; "Birds of Eastern North America," Chapman; "Birds of Village and Field," Merriam; "Guide to the Birds," Hoffman; "First and Second Book of Birds," Miller. For 5 see "Farmers' Bulletin No. 54, U. S. Department of Agriculture"; "Birds in their Relation to Man," Weed and Dearborn.

Nature-Study is not merely the adding of one more thing to a curriculum. It is not coordinate with geography or reading or arithmetic. Neither is it a mere accessory, or a sentiment, or an entertainment, or a tickler of the senses. It is not "a study." It is not the addition of more "work." It has to do with the whole point of view of elementary education, and therefore is fundamental. It is the full expression of personality. It is the practical working out of the extension idea that has been so much a part of our time. More than any other recent movement, it will reach the masses and revive them. In time it will transform our ideals and then transform our methods.

Nature-Study stands for directness and naturalness. It is astonishing, when one comes to think of it, how indirect and how unrelated to the lives of pupils much of our education has been. Geographies begin with the earth, and finally, perhaps, come down to some concrete and familiar object or scene that the pupil can understand. Arithmetic has to do with brokerage and partnerships and partial payments and other things that mean nothing to the child. Botany has to do with cells and protoplasm and cryptograms. History deals with political affairs, and only rarely comes down to the physical facts and to those events that have to do with the real lives of the people; and yet political and social affairs are only the results of expressions of the way in which people live. Readers begin with mere literature or with stories of things that the child will never see or do. Of course, these statements are meant to be only general, as illustrating what is even yet a great fault in educational methods. There are many exceptions, and these are becoming commoner. Surely, the best education is that which begins with the materials at hand. A child asks what a stone is before it asks what the earth is.

There are two ways of interpreting nature—by way of fact and by way of fancy. To the scientist and to the average man the interpretation by fact is often the only admissible one. He may not be open to argument or conviction that there can be any other truthful way of knowing the external world. Yet, the artist and the poet know this world, and they do not know it by mere knowledge or by analysis. It appeals to them in its moods, not in its details. Yet it is as real to them as to the analyist. Too much are we of this generation tied to mere phenomena.

Yet poetry is not mere sentiment. The poet has first known the fact. His poetry is misleading if his observations are wrong. Therefore, as I have said, I should begin my nature-study with facts; for facts are tangible, but sentiments cannot be seen. Whatever else we are, we must have the desire to be definite and accurate. We begin on the earth; later, we may drive our Pegasus to a star.

Do not misunderstand. I would not teach nature-subjects in order that the poetic point of view may be enforced. I plead only that the poetic interpretation is allowable on occasion.

—L. H. BAILEY in *The Nature-study Idea.*

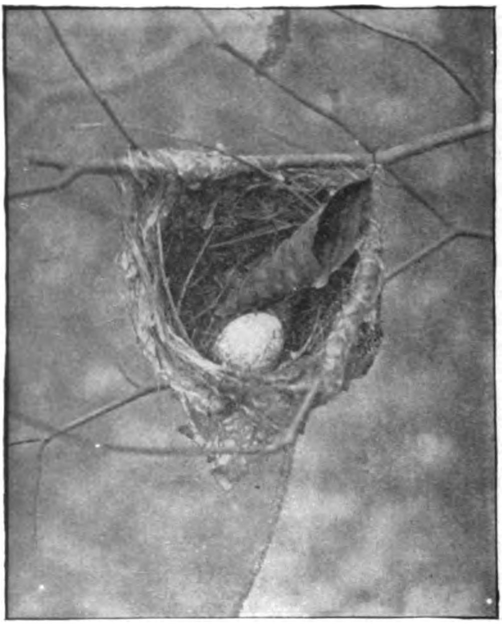


Photo by Verne Morton

Vireo's nest deserted because of the egg of the cowbird in it.

Supplement to

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ANNA BOTSFORD COMSTOCK Editor

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SCHOOL GROUND GARDENS.

By John W. Spencer.

As spring approaches our thoughts turn to gardening and the seedmen's catalogs. There is no reason why the child of the humblest home cannot have something as beautiful as is possible for the most wealthy to own. The thought that plants are not haughty is an inspiration that never becomes threadbare with me. All that they ask is that they may be made comfortable and they will do their part to develop into the best of their kind. In some previous leaflets I have tried to show some underlying principles constituting plant comfort. In this lesson I hope to give some concrete instructions to be applied in securing that end.

One of the drawbacks in helping people to succeed with plants is that they wish to be told by recipes. They seem to think that instruction in cultivation of plants may be given by tablets, to be taken morning, noon and night—that the science of agriculture consists in prescribing panaceas for all troubles in plant life.

For instance we have no inquiry more frequently made than that of "How often shall I water my plants?" I cannot say in reply, Mondays, Wednesdays and Fridays. Plants require watering whenever the earth is dry. A window box or a vase may require water two or three times each day in July or August when the days are the longest and once every other day in September when the days are shorter and the rays of the sun strike the earth more obliquely and evaporation is less rapid.

My suggestions to the one who insists on getting instruction for raising plants as they would mix the materials for a cake — a spoonful of this and a cupful of that and a pinch of something else—is that they had better learn the *why* of cultivation as well as the *how*. Success is not a matter of luck, but rather of doing the right thing in the right way, and at the right time.

There are three degrees or grades of instruction that I would give children in gardening, viz:

The apprentice, as already exemplified in the salad garden.

The garden craftsman, to be described in this article.

The Master gardener, as will be detailed in a future article.

Any one or all of the above may be located and given an adaptation in any of the three following places—the teacher to judge of the circumstances.

The school-ground or vacant-lot garden.

The laboratory garden.

The home garden.

THE SCHOOL-GROUND AND VACANT-LOT GARDEN for children is the most familiar to the general reader and also to the public. It is the only form of garden available in some districts, namely the congested parts of cities.

It lends itself to photographs and lantern slides showing children at work and halftone illustrations are what editors require to give catchiness to an article. For this reason we get but little of other forms of children's gardens in printed descriptions or from the lecture platform. This leads the inexperienced to think that it is the only available way to interest and teach children in matters that relate to the soil and plants. When circumstances make it a case of Hobson's choice—that or nothing—it should be undertaken and much good may be accomplished if the proper person is behind the work. There are other forms of children's gardens that can be adopted, requiring less forced draught than that of a field divided into little plots that are assigned to individual children.

First, the vacant lot type is expensive in that the plan requires an instructor for at least three months of the summer season and four months if the planting is installed in early May and the cultivation continued until early September.

The young gardeners—the more persistent—do well to attend to the cultivation of their assigned plots during that period. With the main walks and path divisions between plots there remains about one-fourth of the vacant lot to be cared for by day laborers. The rent of land is not generally a factor in current expenses for often its use is donated, but plowing or spading, fertilizers, and fencing and a small equipment of tools and tool shed should not be overlooked.

Under the inspiration of spring weather many children enlist, but because of many reasons few remain through the summer campaign to have fruits of victory to show in September. Not all of this is due to children's lack of persistency of purpose. Summer is the season for vacations, visiting and excursions, which lead to partial if not permanent abandonment of plot gardens. The looter or vandal plays his nefarious

schemes more with vacant-lot gardens than with gardens under home conditions. It must be remembered that gardening is not required work, like that of the school room and the child must be held to his undertaking by methods of inspiration rather than that of command. Instruction in each step is necessary, but do not nag. If the boy or girl persists in not observing directions, let the shame that follows failure be the consequence and wisdom may follow the mistake. It is well to let the proprietor of the garden have some latitude in the choice of what he plants, as far as such is reasonable. Make free use of that inspiration that comes from pride of ownership.

Finally let me say that if the vacant-lot garden is the best form that you have, make the most of it if you are quite certain of the funds to bear the expense.

Do not be discouraged because there may be a hundred enthusiastic beginners in the spring and but a fraction of that number in the fall. In every university there are more freshmen than seniors.

A LABORATORY GARDEN is a strip of soil on the school grounds primarily for demonstration purposes only.

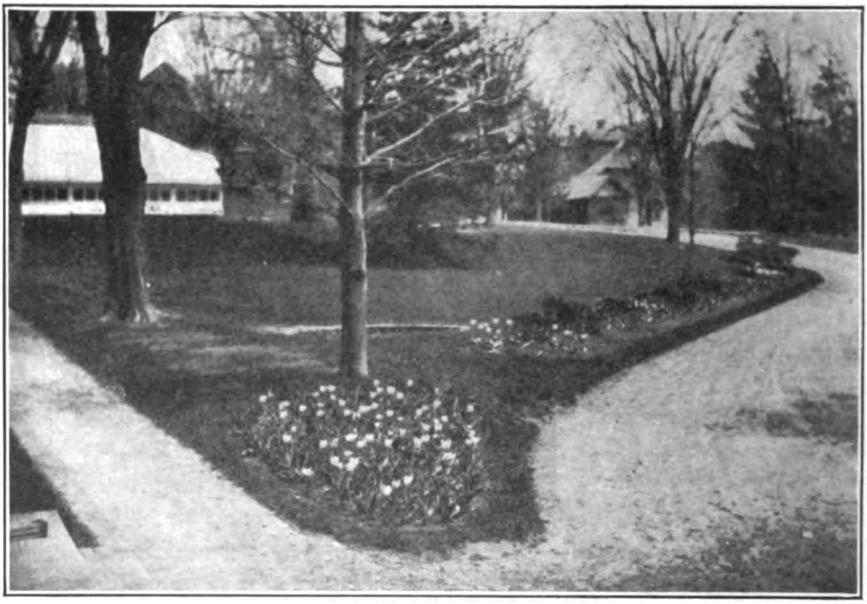
The soil as you find it may be poor for the purpose; it may lack fertility; it may be a tenacious clay, or filled with stones and the debris from the cellar of the school building. Temples of learning are never located with a view that the soil is adapted to agricultural teaching. Overcoming such difficulties will make good instruction. It may be teaching by the negative, but in the negative lies many good lessons. (See suggestions to teachers. page 35, New Series No. 3.)

This laboratory may be composed of strips of land located at the sides or back of the school ground, provided such location is not in the way of school games. Its use would be during the spring and fall months, with no idea of taking a plant through all the summer from seed time to harvest. Lessons of germination of seeds could be given, method of planting, sowing and tillage until the school closes in June. Specimens of most farm crops may be sown, many of which will be far enough developed to show leading characteristics for identification. There is a large list of forage plants, grasses, clovers, etc., many of them biennials or perennials, that can be sown and most of them may be made permanent on the grounds. Planting a plot of this kind is practicable and valuable for the rural school. I venture to say that it is a well-informed farmer who knows more than half a dozen grasses and as many clovers.

In the laboratory garden there may be a "Catchall corner" where a little of anything may be planted for the purpose of watching developments and future identification. Children are fond of collecting spring

flowering plants from the woods and young plants from the field and wayside, all of which may be candidates for the "Catchall corner." When the plants become matured they may be a medley of thistles,—golden-rod, poke berry and brambles,—in fact all the weeds of the neighborhood. When the "catchall" has become permanently established let it be separated from the rest of the laboratory garden and watch the battle for supremacy go on for a few years and note the victorious plants.

To the person who worships tidiness and cares nothing for a fight for supremacy, such a corner would be considered an eyesore. To me such



Bulbs growing in a place which will be very shady later in the season.

a contest rouses my sporting blood and I watch it with keen delight. I once saw in June a deligthful combination—accidental of course—of white daisies and bachelor's buttons.

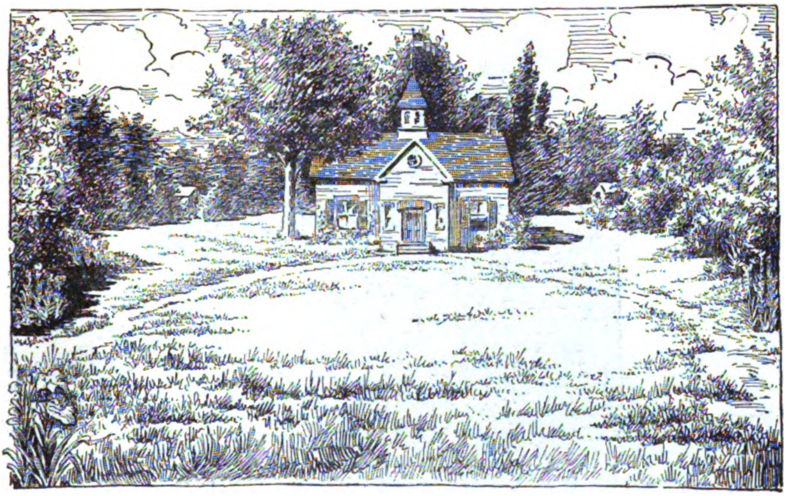
The laboratory garden may be be a place of many resources. Some permanent planting of a few—very few—trees, some flowering shrubs and perennial herbaceous plants and also of fall planted bulbs.

It is an axiom that two things cannot occupy the same place at the same time but in planting there is such a thing as two plants occupying the same ground and one succeeding the other with the changing seasons.

This is true when early bulbs are planted at the base of flowering shrubs. Many experiments in germination may be made beneath the branches of a rose or lilac.

The school laboratory planting on the border of the school grounds is an adaptation of one of the fundamental principles in effective landscape gardening—that of constituting a frame about the school buildings.

Bulletin 160 Figure 27 illustrates the frame idea of which I speak. Unfortunately many persons plant all things between the building and the street as a merchant would put his goods in his show window. This is a mistake. See Bulletin 160 Figure 26. Fortunately, border planting



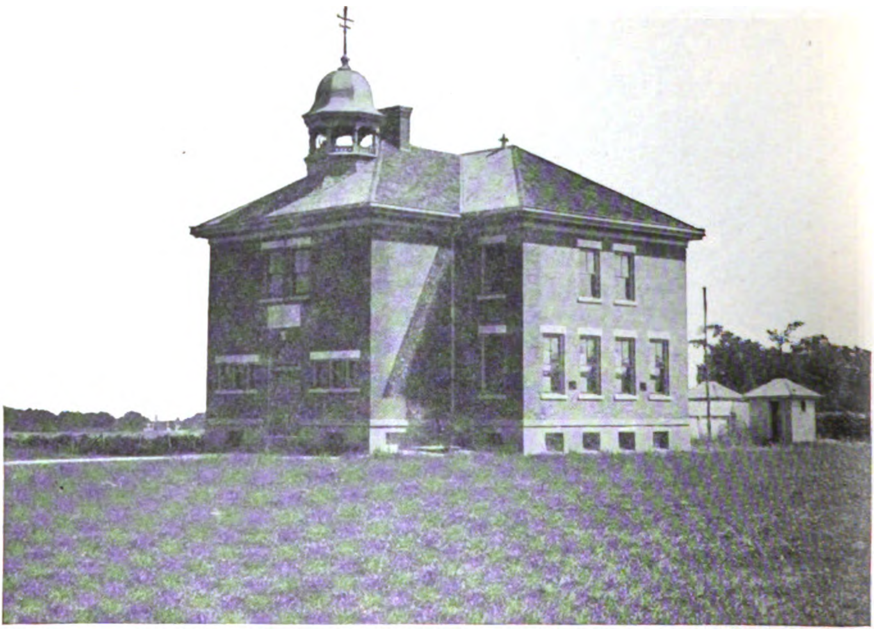
A picture, of which a school house is the central figure.

as shown by Fig. 25 is well adapted to school grounds where the more open part is used for a play-ground and the borders for planting.

For a vivid illustration of what planting will do for the appearance of a school building I would call your attention to the picture on page 6. You have the evidence that it was built for a temple of learning because of the flagstaff. Otherwise it looks like a barrack—a pile of bricks in a desert. I can well understand why the children should have no love for it, should make faces at it and have an impulse to throw stones through the windows. On page 7 is shown another building that when it came from the contractor's hands must have had about the same look as had the first. Study the difference in appearance. The children would have no occasion to be on bad terms with its looks. In fact they

might easily fancy that they were about to enter the home of a local banker. Proper planting has made all the difference.

If I were asked to give details how to convert the building, that the children hate and feel like quarreling with, into one of which they would be proud, I should lay out a plan that might be carried on by the children for a series of years. The first step would be to establish a good lawn. A good lawn can be had only on good soil and good soil is composed of an ample supply of humus added to stone flour (see suggestions to teachers, page 35, New Series No. 3). We must accept conditions as we find them and if not up to all requirements we must remedy them.



Bare and cheerless for lack of trees and shrubs.

PLANTING OF TREES.

SELECTION. The most popular is the hard maple.

Whether it is the best or not depends on circumstances.

A serious drawback is its slow growth. I know a roadside row of hard maples planted sixteen years ago that now have a diameter of perhaps four inches when measured four feet from the ground. The soil is fertile enough to give a yield of three tons of Concord grapes per acre.

I know of another row planted twenty-eight years ago that has not been maltreated by the telephone men that are only about six inches in

diameter. The children can identify the hard maple by the leaf and habit of growth of tree as shown on page 15. When several hard maple trees are available an interesting object lesson may be given the pupils by tapping them during the sugar season in March.

THE SOFT MAPLE develops much faster and has that important feature to recommend it. The branches are long and slim, making an open head. The wood is brittle and suffers during gales, because of the wind breaking the branches. The tree being a rapid grower soon recovers from such accidents if the broken limbs are immediately removed and a smooth surface left where the branches are cut out.

A plain building made beautiful by careful planting.

THE NORWAY MAPLE has admirable habits; it is low headed; quite opposite of the Gothic type of the hard maple; it has dense foilage and makes an intense shade,—so much so that some object to the scanty growth of the grass beneath it.

THE CAROLINA POPLAR is a tree that will grow under any conditions. The soot and dust of the city does not discourage it in the least. I know of a farm home set well back from the road where an avenue of Carolina Poplars was planted about ten years ago. They have grown uniformly as to size with no gaps made by missing trees and give great attraction to the place. The owner started the limbs near the ground a custom I would urge all to follow.

If evergreens should be chosen, I know of none more certain to live

and make faster growth than the Norway spruce. I should not, however, select evergreens for planting where care cannot be given.

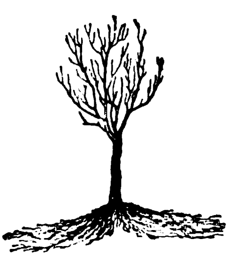
THE BALDWIN OR NORTHERN SPY APPLE to my taste makes a good shade tree. The Baldwin will come into bearing from eight to twelve years after planting and the Spy several years later. The fruit will have no commercial value unless the trees are sprayed.

Should the ground be wet there is no tree like the willow.

Many other trees could be described but here are enough for a selection. In making a choice consideration must be given to the ability of the tree to overcome the vicissitudes to which most shade trees are subjected. I know of none of greater fortitude than the Carolina Poplar, and if properly started with low branches, it need not be held in the light of a poor relation among trees.

In selecting trees, I invariably practice and advise the choice of small trees. This notion of mine comes from my years of experience as a commercial orchardist. A small tree, one that has a diameter of three-fourths to an inch when measured six inches from the ground is cheaper and more certain to live and in a few years will overtake the larger tree of twice its size. The point of view of the professional landscape gardener is different. He advocates large trees, entailing in some instances an expense of $150 per tree. This is possible when the clients are members of Park Boards or are people of ample means. It often happens that such large trees moved by machinery made especially for that purpose make but little if any new growth although they may live for many years.

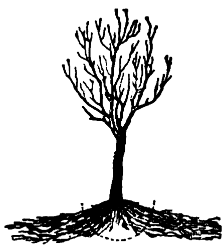
HOW TO PLANT A TREE



How to plant.

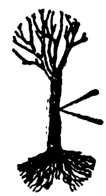
A tree standing in the soil of its birth has in a general way as many roots as it has branches. These roots spreading out in the soil cover as wide an area as the branches, very much as you see in the illustration, and get plant food and moisture from at least a wagon load of soil. In digging up the tree the greater portion of the roots are left behind leaving but comparatively few to go with the tree as you see in the cut on the next page. In this restricted condition the roots are not capable of reaching out and finding nourishment from more than a half bushel of soil. It is easy to see that if planted in its present form the roots and branches are out of balance.

The branches formerly demanded all the resources of that wagon load of soil and now have only the resources of that half bushel. In other


How to trim the roots.

words the demand is greater than the supply. The remedy is to cut back the branches to match the roots as seen in the picture below. To the novice this will seem like heroic plant surgery and the exclamation is " what a waste of growth,— years will be required to replace the severed parts." Such will not be the result. The first important step in replanting all trees and plants is to provide an early and abundant root growth and the aerial growth will inevitably follow. In severing the roots the ends that go with the tree are often badly mangled and should be shaved smooth with a knife. The smoothness is important so that the end may form callouses and from the callouses new working roots will grow.

The hole to be dug in the earth for the roots should be large enough in diameter that they may not be cramped and deep enough that when the planting is completed the tree stands only an inch lower than when it stood in its birthplace. In filling the soil about the roots great care must be taken to have the grains of soil snuggle close about all of the fine roots. To make sure of this the filling should be done in three stages. After filling the first third, half a pail of water should be dashed over the soil in the hole; this washes the fine soil close to the roots and also gives extra moisture. The second and also the third stages are a repetition of the first.


Trimmed.

In commercial planting, the trees are received from a nurseryman with the roots packed in damp moss and they should never be permitted to become dry. A common practice is to dip the roots in mud and then throw a blanket over them until planted as described above. The points given above are necessary in all planting, whether of trees, vines, shrubs or perennials, and the process will not be repeated when speaking of other plantings that may follow.

SHRUBS

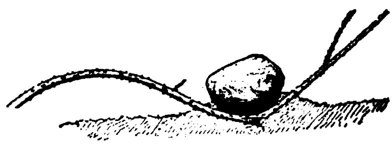
SELECTION. The first I shall mention is the sumac. It will survive the replanting if given half care. When I see the bean pole Arbor Day maples either dead or in a death struggle I wish that the sumac could have had the chance of the maples. It is certainly a thing of beauty in the fall months when school opens. Because it is common and considered as brush by the farmer is no reason why it should not find a home on the school grounds. The world is too much given to underrating things because they are common. It is true that its power

of motherhood is so strong that in a few years it may encroach on adjacent territory, but that tendency is easily controlled by the mattock. The red fruit growing at the ends of the branches and the content of tannin will serve as subjects for object lessons and as such will receive more attention when planted on the school ground than when growing in fence corners and among stone piles. It has two ways for extending its occupation of the soil, first by extension of roots and sending up shoots and second by dissemination of seeds. The first is the one the farmer considers the most aggresive.

The LILAC is a desirable shrub for the school ground, as it blossoms before the close of school in June. When once firmly established it will take care of itself against most other competitors, needing but an occasional pruning. It has seed of course but the usual methods of propagating are by cutting, layering and by division. If the plant is of several years' growth shoots spring up about the main stalk, something after the manner of the sumac but not with the same aggressiveness. In neighborhood distribution these shoots are dug for planting. Before the young lilac can make much growth fine roots must be developed. Moisture is an important factor in doing this and if the soil is not naturally moist the shoots should be kept well watered until root growth has started. If some leaves or straw is placed around or an inverted basket or pail is placed over the lilac for two weeks, thus protecting the soil from loss of moisture, favorable conditions will follow. This is an opportunity for the children to distinguish leaf buds from blossom buds. Do not fail to cut the stem back leaving not more than a foot standing above the ground. Often blossom buds do not appear until three or four years after planting. The blossoms of the spring of 1908 began developing as buds in the summer of 1907. If pruned in the spring before blossoming the flower buds will be cut away and lost. When pruning is necessary do it immediately after blooming has passed and no blossom buds have formed.

The ROSE is considered the aristocrat of flowers, but all varieties are not suited to the school ground conditions. The earliest to blossom is yellow in color. The "thousand leaf" rose when once established holds its own fairly well, yet it amply repays the kind offices of a friendly hand. It produces seeds, but it is propagated by that means only by growers in search of new varieties. Nurserymen and florists propagate roses by cutting or layering. The latter is comparatively easy for chilren to do and affords a practical lesson in garden craft. As soon as school opens in September choose some of the longest canes and cut a slit on the under side then bend it to the ground and hold firmly in place by weighting with stones, as shown on page 11. Cover the cane over the slip with three

or four inches of soil and keep this soil moist. Better conditions for moisture can be maintained by inverting a basin or pail over the spot. The soil should be made mellow before bending the cane. A callous will form on the edges of the slit and from the callous roots will appear. When the roots are four inches long the cane may be cut between the roots and the bush and thus a new plant has been created.



Layering a rose cane.

If the children bring roses from their homes for planting, the shoots like those spoken of in lilacs are the most frequently used. The same method for planting roses should be followed as given for lilacs. The same directions apply to planting the forsythia, flowering currant, syringas, and flowering quince. Spirea Houtii is a phenomenal bloomer and will be greatly prized. The directions given for planting trees apply to all of the above shrubs.

I will not enlarge the above list. There are others just as good but these are reliable and when once well established in a school ground require but little attention each year. A mulch of leaves should be put about the roots each fall and if permitted to remain to rot the following summer, fertility will be added to the soil, moisture maintained and a check given to the growth of weeds.

PRUNING. Aside from roses, spring pruning is not important until the shrubs become so large that a little clipping here and there is needed to check side growth and to give proper form. Cutting out old wood and winter killed tips is always in order.

It is practicable to plant tulips and narcissus beneath any of the above mentioned shrubs. The bulbs are through with the soil and sunshine before the foliage of the shrubs seriously shade the ground and the season of the year is such that the soil contains plenty of moisture for both.

PERENNIALS

I can hardly overrate the merits of perennials for school-ground planting — or planting for the lawn and special flower gardens for that matter. The list that I shall give is only a fraction of the group, and the ones that I have mentioned will have a part if not all their period of bloom while school is in session in spring or fall. Only a part of the list given should be planted under conditions usually found in school grounds. The list is made up much like a menu card — something to select from.

In my directions for planting trees and shrubs I spoke of digging holes in which to plant them. For perennials the soil should be spaded, pulverized and otherwise given the same good tillage as for planting annuals. If the soil seems hard and lumpy, having an over proportion of stone flour and an under proportion of humus the latter should be added (See page 35, New Series, No. 3). If stable fertilizer is not available use rotted leaves. These may be made the means of a vivid lesson on Nature's methods of making soils. The gathering of leaves in the autumn and spreading them around all plantings, there to remain to rot has a threefold use; that of getting rid of the litter on the lawn, protecting the plants, and giving fertility. Be it understood that stable fertilizer gives quicker results and bulk for bulk is stronger than rotted leaves. Taking a period of five years the custom of piling leaves as spoken of above will put the soil in an ideal condition. The leaves when dry should be spread a foot deep.

PERENNIALS FOR SCHOOL GROUND

Sweet William is the first that I would mention. It belongs to the pink family. It may be propagated from seed or by division. If the children bring a supply from their homes, they will probably bring a division of an old plant or perhaps a self-sown seedling.

By " seedling " I mean young plants produced from seeds and not by division of roots or by cutting. I once received a letter from a boy who called them " veal plants." Another boy asked me if seedlings were plants just weaned from the lunch of starch found in the seed and now beginning to make their own living from the soil, sunshine and air.

The seedlings would be the better, for Sweet William feels its years sooner than many other perennials. If a border of perennials is already established on the school ground seed of the Sweet William may be scattered in some friable soil beneath some of the shrubs and later when they are an inch or more high can be removed to a permanent place. In my experience some bloom appears the spring following the planting of seed and an abundance of bloom the second spring. The colors comprise many tints of red. The stems are stiff and for bouquets at a distance, say from desk to seats in the school room the effect is good, particularly when mixed liberally with green. It is important that the blossoms be picked and no seed allowed to form.

AQUILEGIA OR COLUMBINE is another spring bloomer. My collection of this perennial I have obtained by sowing seed in September and replanting the youngsters the following spring in permanent places. As

proof that Columbine is persistent and has the ability to endure neglect and hold its own against competition I would point to the fact that they may be found about abandoned farm homes or lingering on the lawn after a house has been burned. The plants under favorable conditions spread out from the original plants by stooling. Children are greatly amused by watching the bees wiggle in and out of the blossoms.

FOXGLOVE is another June bloomer and may be had by a division of the plants or from fall seedlings. It, too, is persistent in holding its own against competition. The shades of color of the flower may be called soft. The flower spikes may be cut at the time of the opening of first blossoms and the remaining buds will develop in a vase of fresh water.

GERMAN IRIS OR FLEUR-DE-LIS will succeed under many discouraging conditions and it will hold its own in competition with chickweed, but will show signs of weakening if there is a combination of chickweed, pigweed and grass. It delights in a moist soil which at times may be wet, under which conditions I have seen it persist season after season in a meadow. It will accommodate itself to a gravel soil if kept moist and well cultivated. In my own planting this is the only location that I am able to give it. The bloom is satisfactory in all respects and the increase in size of plant goes on each year. I am careful that it has no competition with weeds and has a mulch during the hot and dry periods of summer.

The above four perennials with fall planted bulbs will make a fine combination of an abundant supply of flowers from early spring until school ceases in June. In my experience with their culture none of them have insect or fungus troubles.

The following belong to what I would class as a subsidiary list as compared with the one given above:

PANSIES AND ENGLISH DAISY. These two may be called comrades in their sufferings from the heat and drouth. Both prosper in extra fertility. Each belongs to the cool loving plants and are sure to give abundant bloom in the spring when men wear overcoats and women furs. The pansies are particular favorites of children.

LILY OF THE VALLEY. One of the best to withstand shade. In fact I should say it requires shade. It may be obtained by division of roots. Its vigorous spreading of roots is a good illustration of Motherhood and withstanding of competition. When a colony is once established under favorable conditions it will drive a grass plot to the wall. Roots should be planted three inches deep.

PEONIES. The old sort with its garish red is a favorite color with boys and generally with girls. Of late years the newer sorts have softer colors. The increase is by roots or "toes.' Under favorable conditions

these will increase to the extent of congestion and should be redistributed by one " toe " to each new plant.

CROWN IMPERIAL. A stately flower stalk and comes with the fall planted bulbs. It is one of the first to show spring growth. Strictly speaking it belongs to the bulbs and may well be classed with the fall bulbs so far as the time of planting and bloom is concerned.

HARDY CHRYSANTHEMUM. This is the flower latest in blossom that I would recommend for school-ground planting. When well-established on well-drained soil and given winter protection of leaves, good results will be obtained, the bloom continuing after the coming of several frosts. They are propagated by division of the roots.

In the spring when children — and grown people too — are flower crazy and bring back from their excursions in the woods the spring blossoms and ferns, let them plant them promiscuously among the flowers mentioned above. The trophies will retain their freshness longer when put in the ground than out of it. Some of those having roots may live and blossom during other springs. Some of them may pass out of view during the summer to surprise you the following spring like a friend calling unexpectedly.

I have tried to give the fundamental principles of planting in the paragraphs on planting trees and have not repeated them since because I have thought the repetition unnecessary. The points given are fundamentals and should always be observed in planting and transplanting of shrubs and herbaceous plants.

CLIMBERS

On the part of many people there exists a prejudice against vines clinging to the sides of buildings. In some instances there may be an ounce of reason for objections, but it is quite sure to be mixed with a pound of prejudice.

TRUMPET VINE. This is my first choice for school-ground planting, it is a rank grower and has no insect or fungus troubles that I know of. There are many situations where it may be used with good effect other than that of climbing over the school building. A skeleton of an arbor or children's play-house the delight of the girls — may be made of rough poles about which may be planted trumpet vine. But a few years will elapse when the vines will be holding up the skeleton rather than the reverse. The boys of the school may want a summer arbor too but not for a play-house. That would be effeminate. Let the girls have that. The boys will call theirs a wigwam and it will be the starting point for

the untamed Indian on his raids. Two of these arbors may be made and one may be made popular with the boys by giving it the attributes of a wigwam rather than that of a play-house.

Boys and girls rarely agree in doing the same thing in idealizing life.

There are out-buildings and fences and the flagstaff to support the climbers and the captious cannot object to the use of vines in such locations.

AMPELOPSIS. Two kinds of ampelopsis are in frequent use. That known as Boston Ivy is mostly in use in cities and is well suited for brick and stone walls. The beautiful tints of the foliage during the fall months is beyond description. The other kind of Ampelopsis is commonly known as Virginia Creeper or "five-finger Ivy" and sometimes by the generalized term of woodbine. This can be easily identified from the poison ivy which has but three leaflets.

CLEMATIS. This is finer in foliage than the vine described above and has a place about homes but may not withstand the rough usage so likely to come when located on the school grounds. The *Clematis paniculata* has a popularity and blossoms in the fall after school begins.

THE HONEYSUCKLE has a deserved popularity but has an insect enemy — the aphis — and therefore must be frequently sprayed with strong soap suds. The aphis, being a sucking insect, cannot be reached by poisons and must be attacked by applications on the body.

Sugar maple.

A sugar maple grown in an open field.

CORNELL
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Over the hill the farm-boy goes.
His shadow lengthens along the land,
A giant staff in a giant hand;
In the poplar-tree, above the spring,
The katydid begins to sing;
The earley dews are falling;—
Into the stone-heap darts the mink;
The swallows skim the river's brink;
And home to the woodland fly the crows,
When over the hill the farm-boy goes,
Cheerily calling,
"Co', boss! Co', boss! Co'! Co'! Co'!"
Farther, farther, over the hill,
Faintly calling, calling still,
"Co', boss! Co', boss! Co'! Co'!"

JOHN T. TROWBRIDGE.

LESSON I. NO TWO PLANTS ARE ALIKE. Figs 1 and 2.

By L. H. BAILEY.

Object.— To acquaint the learner with the great fact of variation, that no two plants or animals are duplicates, that all living things have individuality. This is the first generalization that the pupil should make about animals and plants.

The materials are any two or more plants of the same kind, or any two or more animals. For the present, we will confine ourselves to plants. A row of corn, of beans, of potatoes, of China asters, a number of stalks of wheat or grass, a number of trees or bushes, afford facilities for the study. Any two plants anywhere give the facts.

The method is to see a plant accurately and then to compare it with another plant of the same species or kind. In order to direct and con-

centrate the observation, it is well to set a certain number of attributes or marks or qualities to be looked for.

Suppose any two or more plants of corn are compared in the following points, the pupil endeavoring to determine whether the parts exactly agree. See that the observation is close and accurate. Allow no guess-work. Instruct the pupil to measure the parts when size is involved.

1. Height of the plant.

2. Does it branch? How many secondary stems or "suckers" from one root?

3. Shade or color.

4. How many leaves?

5. Arrangement of leaves on stem.

6. Measure length and breadth of six main leaves.

FIG. 1.—*No two plants in this row of corn are alike.*

7. Number and position of ears; color of silks.

8. Size of tassel and number and size of its branches.

9. Stage of maturity or ripeness of plant.

10. Has the plant grown symmetrically, or has it been crowded by other plants or been obliged to struggle for light or room?

11. Note all unusual or interesting marks or features.

12. Always make note of comparative vigor of the plants.

If the corn is already cut, make the comparisons from stalks taken from the shock; or apply a similar method to some other plant. Similar work can be done with any large branch of a tree, comparing all the

twigs or shoots on the branch. Any seedlings standing thick in a pot or box soon develop differences; or differences may be apparent from the first. No difference between plants is too minute to be overlooked, not even to the notching of the edges of the leaves. Nothing in nature is so small or trivial as to be disregarded.

LESSON II. THE CONSTITUENTS OF MILK. Figs. 3 and 4.

BY RAYMOND A. PEARSON.

Object of lesson.—To acquaint the pupil with some of the contents of milk; to give fundamental preparation for a series of lessons on milk; to lead the pupils to realize the importance of this subject for study.

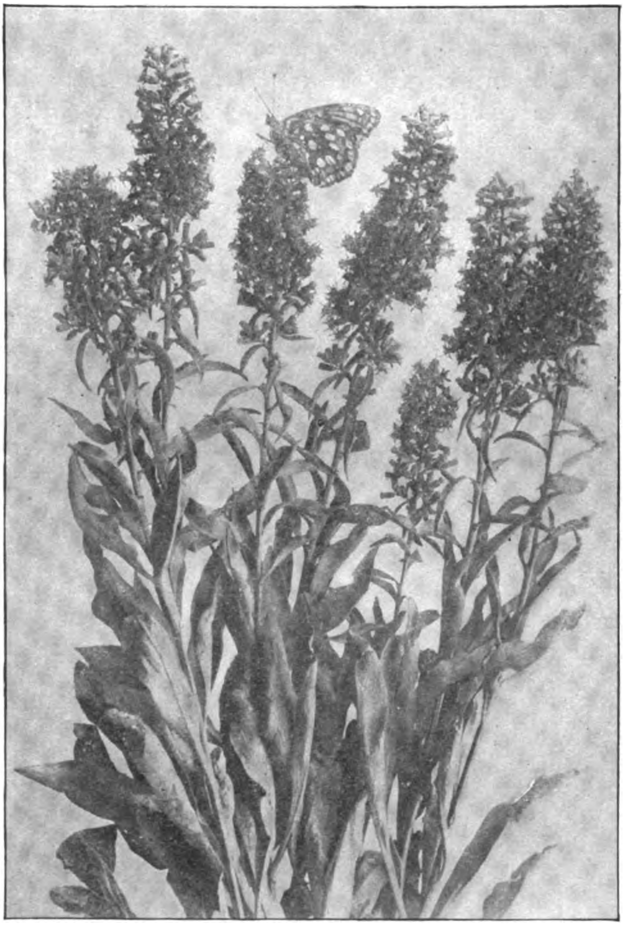


FIG. 2.—*Even these stalks of golden-rod, all coming from the same root, are different one from the other.*

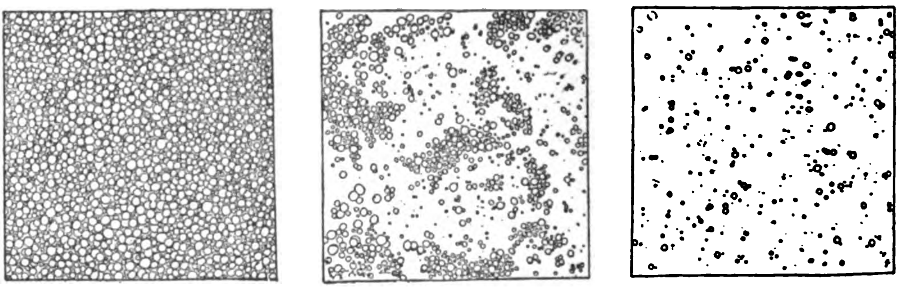
Materials.—Thermometer, bottle, saucer, pan, a few drops of vinegar, and one quart of fresh milk.

Milk consists of about seven-eighths water and one-eighth substances which are in solution in the water or floating in it in very small particles. This may seem to be a large proportion of water and a small proportion of valuable constituents, but many fruits and vegetables have even more water, and some of our favored meats have

enough water and bones and other matter useless for food to equal the amount of water in milk.

The constituents of milk are often referred to as *water* and *total solids*. The latter includes all the substances except water, and they collect in solid dry form when the water is evaporated, as may be observed by leaving a little milk in a saucer for a short time in a warm place. There are five different substances in the total solids: fat, casein, albumen, sugar and ash. It is an interesting exercise to separate them. The chemist can do this with great accuracy, but any person can do it roughly with such aids as are found in the kitchen. A gross analysis of milk may be made as follows:

For the fat.— Let one quart of fresh milk stand quietly in a pan in a cool place until a rich, clearly-marked layer of cream gathers at the top. This cream is formed by the rising of countless balls or globules of pure milk fat, often called butter-fat, which is distributed evenly through



Cream. **Milk.** **Skimmed milk.**

FIG. 3.—*Showing appearance of milk through high-power microscope.*

perfectly fresh milk or milk that is frequently stirred. The fat is so much lighter than the fluid in which it floats that most of it will be found in the cream layer in twelve hours, providing the milk was fresh when "set" and it has stood undisturbed in a cool place.

The cream should be removed by skimming or dipping, warmed to about 60° F. and shaken in a bottle which is only partly filled. Soon the fat globules will unite and form light-yellow granules large enough to be seen. The shaking or churning should be continued until as much fat is collected as possible. After it is washed a few times in clean, cold water it is seen in an almost pure state. This fat is the principal constituent of butter and also one of the principal constituents of cheese.

For the casein.—A few drops of acid (or vinegar) should be added to the skimmed milk which was left after the cream was taken off. Soon it will coagulate or thicken. It should then be gently warmed to about 100° F. and carefully broken by a knife or spoon into a few pieces. The

skimmed milk will slowly separate into curds and whey. When the whey amounts to more than half of the quantity of milk used, it should be removed by pouring through a cloth strainer. The casein remains in the cloth. It is one of the principal constituents of cheese.

For the albumen.— Slowly heat the whey to 160° F. It will become somewhat cloudy and soon a soft jelly-like substance will collect on the surface. This is albumen which was coagulated by the heat. It is similar to the albumen or white of an egg. It should be separated by straining. This constituent is not used in the manufacture of butter or the ordinary varieties of cheese.

For the sugar.—A small quantity of whey which has been freed from its albumen is placed in a clean porcelain dish with a large bottom (as a saucer) and this is warmed, care being taken not to burn it. It may be warmed in an oven with the door partly open. When the water has

FIG. 4.— *The constituents of a quart of milk.*

Water	Fat	Casein	Albumen	Sugar	Ash
87%	4%	2.6%	.7%	5%	.7%
29.93 oz.	1.38 oz.	.89 oz.	.24 oz.	1.72 oz.	.24 oz.

evaporated, a dry substance remains. This is about seven-eighths milk-sugar and one-eighth ash. It is not practicable to separate the sugar in pure form from the ash. Sugar is not present in large quantity in either butter or cheese.

For the ash.—A part of the mixture of sugar and ash is placed in a dish which will withstand high heat, or on the stove cover, and allowed to burn as long as it will. The small amount of incombustible matter left is milk-ash. It is not an important constituent of either butter or cheese.

The amounts of the different constituents in different milks varies somewhat, but the following shows the percentage composition of average milk and about the quantity of each constituent in one quart, which weighs 2.15 pounds:

	Per cent	In 1 quart	
Water	87	29.93	ounces
Fat	4	1.38	"
Casein	2.6	.89	"
Albumen	.7	.24	"
Sugar	5	1.72	"
Ash	.7	.24	"
	100	34.40	oz.

LESSON III. THE PARTS OF AN EGG. Fig. 5.

(*For advanced pupils.*)

BY JAMES E. RICE.

Object.—To teach the structure and function of the egg, to demonstrate natural physical laws which are there illustrated, and to train the pupil in accuracy of observation.

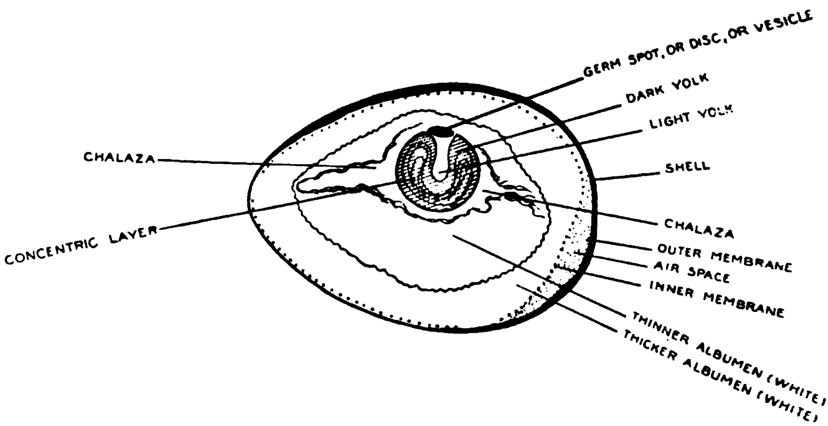


FIG. 5.—*Diagram of a hen's egg, in longitudinal section.*

Suggestions to the teacher.—This practical exercise can be given best by affording each pupil an opportunity to observe for himself the points to be brought out in the lesson. This can be accomplished in progressive steps by a statement of the things to be done and to be observed. Later, the observation can be aided by blackboard or chart illustration showing roughly in colors the structure of the egg, with a printed word description by which the pupil may compare and correct his drawings.

Materials.—Each pupil should be supplied with two eggs, one with light shell, the other with dark shell if possible; two saucers; one drawing pencil; one box of colored lead pencils; and a knife.

For the general use of the class there should be a good lens; an alcohol lamp and kettle, or other facilities for boiling eggs; an egg-

tester; blackboard and color crayons; and preferably also a chart showing an enlarged, longitudinal section of the egg, with its various parts in colors.

An egg-tester can be made by placing a lamp with chimney in a box with a hole cut through the side slightly smaller than the egg. By placing an egg over the opening in a darkened room, the interior of the egg can be plainly seen. The same result can be accomplished without an egg-tester by enveloping in the hands the egg in a darkened room and looking through a small opening in the curtain at the sun.

Any teacher who is unable to secure the above materials should take such parts of the lesson as he can teach with the material that is available. We have tried to make the requirements very simple, but if teachers cannot meet them, the greater part of the lesson can be given without them.

1. *Strength of the egg shell.*—Let each student hold a hard-shelled egg between the clasped hands, the ends of the egg in the hollow of the hand, and try to break it.

Observe the great strength of the egg due to the arrangement of the particles of the shell in an arch similar to the stones or bricks in the arch of a bridge.

This arrangement gives the egg great resistance against injury to the shell, or to the chick which is developing within the egg.

2. *The contents of an uncooked egg.*—(a) Break a fresh, uncooked egg in a saucer by separating the shell in the middle.

Observe the "germinal disc," which appears as a light-colored spot usually to be found on the upper surface of the yolk.

The germinal disc contains the life principle of the egg. On the upper surface it remains in close contact with the source of heat during natural incubation, which is from above.

(*b*) Note the *"chalaza,"* or the whitish cords of denser albumen on the sides of the yolk toward either end of the egg. These cords of denser albumen serve to keep the yolk properly suspended within the albumen. Thus the chick which develops on the upper surface of the yolk is protected from injury, if, through rough handling, it should come in contact with the shell.

(*c*) Note the transparent, watery appearance of the albumen (white of the egg).

The albumen supplies the food in liquid form by which the chick grows within the shell.

(*d*) Examine the shell and note the air-space usually found near the large end. Observe the brittleness of the shell and the two tough membranes best observed at the air-space, where the membranes separate.

The air-space furnishes a readily available supply of fresh air to the

embryo chick. The two membranes prevent the too rapid evaporation of moisture through the pores of the shell, but allow oxygen to enter the egg and carbon dioxid to pass out.

(*c*) By placing a section of the shell under the lens, indentations or pores in the shell may be observed.

These thinner parts permit the gases to pass more readily through the shell. If the pores of the shell are closed by oil, varnish, dirt or broken egg, the pores will be closed and the chick smothered.

(*f*) Note the pigment of the shell, which gives to each egg its characteristic color.

Observe in nature how the first eggs laid for a brood are more pronounced in color, and how the color pigment decreases with each egg that is laid, due to exhaustion of the supply.

3. *The content of a boiled egg.*—Crack carefully, on the large end, the shell of a hard-boiled egg; remove the shell carefully piece by piece to avoid tearing the shell membrane.

(*a*) Observe the air-space and the two membranes, which are separated with difficulty. Note that the outer membrane is the thicker and tougher.

(*b*) Cut the egg lenthwise through the middle. Observe the lighter-colored flask-shaped center of the yolk and the darker yolk arranged around it in concentric layers. Note the "germinal vesicle" or "germinal disc" at the upper part of the light yolk. Observe that the yolk is at one side and not in the center of the white of the egg. Note also that the germinal disc is on the upper side of the yolk. This is because the yolk is lighter in weight than the albumen and hence floats. The germinal disc on the surface of the white yolk is lighter than the dark yolk.

The chemical composition of the dry substance of the inside of the egg is (Snyder: Poultry Book, page 188):

	Protein	Fat
White (albumen, white of the egg)	88.92	.53
Yolk	20.62	64.43

It will be seen that there is a large amount of fat in the yolk and almost no fat in the albumen. Fat is lighter than albumen, hence rises to the surface. This may be observed in practice by holding a fresh egg in front of an egg-tester and noting the tendency of the yolk to float upward.

This tendency of the yolk to float to the surface makes it necessary frequently to turn eggs which are kept for hatching, otherwise the yolk will rise until the germinal disc comes in contact with the shell membrane, which becomes dry by evaporation and allows the vitelline membrane to adhere and thus become ruptured, killing the germ when the egg is moved.

4. *Review.*—Make a drawing, longitudinal section (the outline of an egg 1½ times natural size showing directly from the egg itself):

(a) The shell and its pores. (b) The two shell membranes turned back from the shell. (c) The air space. (d) The three layers of albumen. (e) The vitelline membrane surrounding the yolk. (f) The vitellus contained within the vitelline mambrane. (g) The white yolk and the dark yolk showing its concentric layers. (h) The germinal disc. (i) The chalaza ("hammock cords").

Definitions.

Vitelline membrane.—A delicate film-like skin, which encloses the liquid portion of the yolk of the egg.

Vitellus.—The yellowish-like substance within the yolk of an egg—closed by the vitelline membrane.

Embryo.—The young chick in the first stages of development, before it leaves the shell.

Concentric layers.—Thin layers of yolk substance of different shades appearing to be arranged in rings, one within the other, whichever way the yolk of a hard boiled egg is divided.

Incubation.—The process of development of a chick within the egg, requiring heat, moisture and air.

Chalaza.—A twisted band of thickened albuminous substance (white of egg) to be found attached to the yolk for the purpose of keeping it properly suspended.

Shell membrane.—Two thin skin-like tissues which line the inside surface of the shell of the egg.

Germinal vesicle, germinal spot, germinal disc.—The part of the yolk of an egg undergoing incubation, which contains the first traces of the developing chick.

LESSON IV. THE PEA FAMILY. Figs. 6, 7, 8.

By G. F. WARREN.

Object.—To learn to recognize leguminous plants.

Materials.—One or more hand lenses, bean or pea blossoms and pods, clover blossoms, and as many other legumes as possible. (See Rural School Leaflet for September, p. 7.)

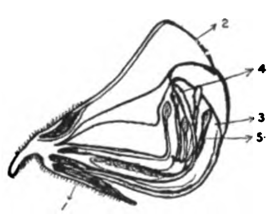


FIG. 6.—*Pea flower cut in two.* 1, a sepal; 2, standard or banner (one of the petals); 3, keel (part of the corolla); 4, style; 5, stamens.

The group of plants that is most important to mankind is the great grass family (*Gramineæ*) which includes corn, wheat, oats, rye, barley, timothy, and others. One will readily see that all these are much alike, particularly in the leaves and leaf arrangement.

The second group in importance is the pea family (*Leguminoseæ*). These plants are commonly called legumes, or, more properly, leguminous

plants. Later numbers of the Leaflet will tell why these plants are so valuable to us. The first thing is to learn to recognize them.

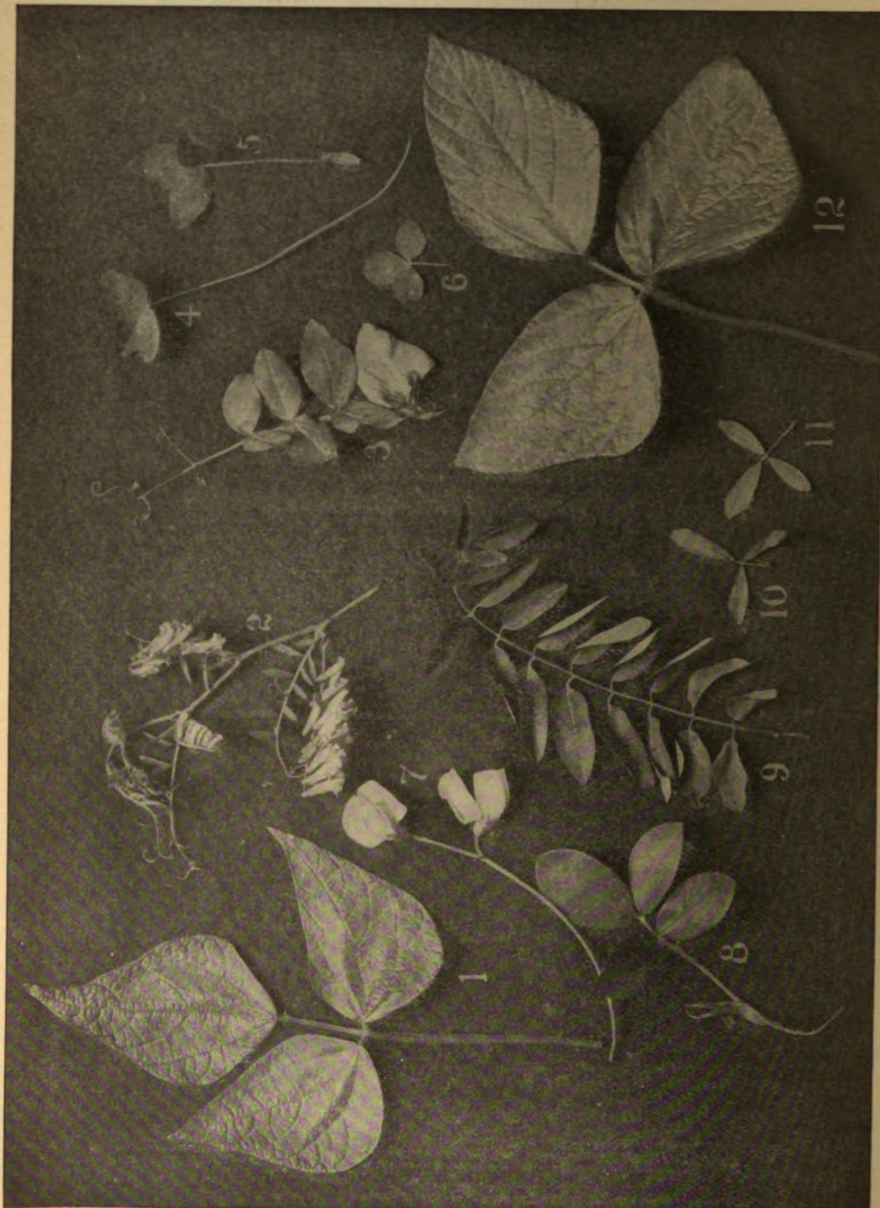


FIG. 7.—*Leaves of leguminous plants.*

1. Bean. 2. Hairy or Winter vetch leaves and blossoms. 3. Pea. 4. White Clover. 5. Red Clover. 6. Alsike Clover. 7. Sweet pea blossom. 8. Peanut. 9. Black locust. 10. Sweet Clover. 11. Alfalfa. 12. Soy bean. The peanut came from one of the Ithaca school gardens. The Soy bean and winter vetch came from the Experiment Station grounds. All the others were collected along the roadside in a ten minutes' walk.

Probably the best way to study the lesson outlined below is to take the class to the field and find and compare all the legumes possible—clovers

of various kinds, alfalfa, sweet clover, peas, sweet peas, beans, vetches, black locust, and all plants with pea-like flowers. Or the work may be given in the school room. The first day might then be devoted to a study of either a bean, pear or clover blossom and to making drawings of it. After this each pupil is to bring in as many similar plants as possible. One or more lessons can then be given in comparing them. At the same time learn the common names.

The following outline for the study is suggested:

How are the leaves arranged?

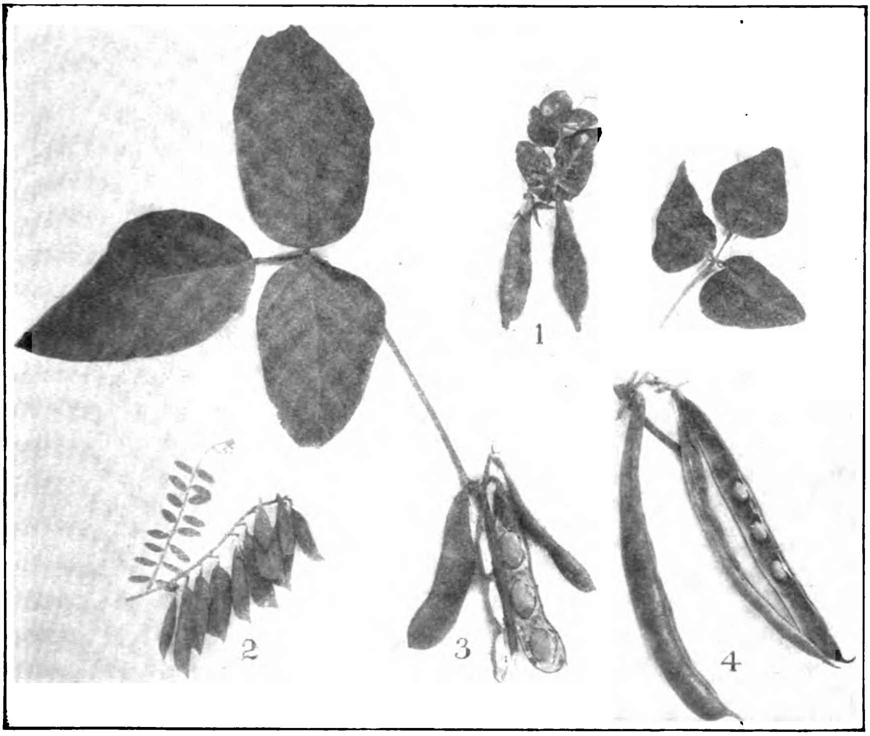


FIG. 8.—*Pods of leguminous plants.*

1. Pea. 2. Hairy vetch. 3. Soy bean. 4. Bean. The opened pods show the characteristics from which these plants derive the name legume.

Are the leaves simple (all in one piece), or compound (divided into several leaflets)?

What two kinds of compound leaves? Draw one of each kind, as pea and clover.

If the class has not learned to recognize the parts of the flower (sepals, petals, stamens, pistil), these should be learned. See Fig. 6.

Examine the corolla and note the shape of its parts. Make a drawing of the blossom.

How many stamens? How are they arranged? Draw them.

Split a pea or bean pod. How does it open?

Make a list of all the legumes that you find growing in the neighborhood and another list of all that are planted by farmers.

The following points will be discovered:

1. The leaves are always alternate, i. e. no two leaves are at the same level.

2. The leaves are compound (there are a few exceptions). The leaflets are arranged along a midrib, as in the pea, vetch, peanut and locust; or they may be palmately compounded with the leaflets coming out like the fingers from the palm, as clover, alfalfa. See Fig. 7.

3. Many of the legumes can be recognized by the shape of the blossom. They are sometimes named the Papillionaceæ family of plants, the word meaning "butterfly-like." Pea blossoms have this butterfly-like appearance. See Fig. 7. The stamens are often surrounded by a more or less boat-shaped part of the corolla. This part is called the keel because of its similarity to a boat. Many of the legumes can be told by this boat-shaped appearance. When examining clover, remember that the head is made of many separate blossoms.

4. There are usually ten stamens, nine of which are united around the pistil and one of which is commonly independent.

5. The pods split along both sides into two parts. The name "legume" refers to this characteristic. The word is used to denote a simple dry seed-pod that splits along both sides, with the seeds on one edge of it. This characteristic is more difficult to distinguish in very small seed pods, as those of clover. The word "legume" is now commonly used, however, to mean a plant that bears a legume.

If you find any legume whose common name you do not know, send a specimen with blossoms and seed pods, and we will give the name.

Words to be spelled and defined.

Legume or *leguminous plant,* a member of the pea or clover family.

Compond leaf, a leaf that is divided into distinct blades or leaflets, as a clover leaf.

Simple leaf, a leaf that is all in one piece, as a maple leaf.

Calyx, the outer part of the flower, usually green.

Sepal, one division of the calyx

Corolla, the inner circle of flower leaves, usually not green.

Petal, one division of the corolla.

Pistil, the central organ of the flower, in the base of which the seeds develop.

Stamen, the organ of a flower that bears the pollen.

Alfalfa, a clover-like perennial legume.

CORNELL
Rural School Leaflet
SUPPLEMENT FOR THE CHILDREN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May. L. H. Bailey, Director.

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

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WEATHER LESSONS.

By Alice G. McCloskey.

"There is a game the children play
In country districts far away,
As quiet as the rains and snows
And native as the grass that grows.
'Wind blows' they call this simple game
And all the fields is in the name."

* * * * * *

"Oh children, children, many a day
I've followed the winds in fields away,
To birds a-wing and the river-flows
To meadows free where the wild phlox grows,
When woods and shores and life were the aim
And texts and schools were only a name.
"And I never will be so old and gray
But I'll track the winds in their wander-way."

L. H. B.

There is one thing that everybody lives with, everybody whether in the city, in the country, on the desert, on the sea, in the jungle, or in the northern lands,—this is the weather. It is, therefore, one of the important subjects in the study of the out-of-doors. Study of the weather is one of the lessons that gives rich return for things that we come to learn in connection with it.

It is worth the while to have the right spirit toward the weather. There are some people who are always complaining about it, finding it either too hot or too cold, too windy or too rainy, too wet or too dry, which shows that they have not learned to know the weather. To one whose spirit grows aright, the rainy day should have its charms just as the sunny day has. One should love both the calm days and the blustery days. He should be "in tune with wind and weather."

Let us have some lessons this year on the weather; let us see how nearly we can touch the real out-of-doors. We might begin with the

winds that are sure to blow these fall days. Let us keep a record of the direction of the winds for the month of October. When finding out the direction of the wind, ask your teacher if you may all go out and let it blow in your faces. Notice what the wind does to the trees. In what way do you think it may be responsible for the shape of trees in your vicinity? Why do farmers plant a row of trees for a wind-break?

As soon as you begin to think about the wind you will probably want to know how it blows. Here is a lesson prepared for you by Dr. Wilson of the United States Weather Bureau. Can you learn from it how the wind blows? Read the lesson very carefully. Then, if your teacher will work with you, go out into your school grounds and prepare a bonfire as Dr. Wilson suggests. I want you to see whether you can find out what happens when the wind blows.

HOW TO MAKE THE WIND BLOW. Fig. 9.

BY WILFORD M. WILSON.

When school begins in autumn, one of the first things to do is to clean

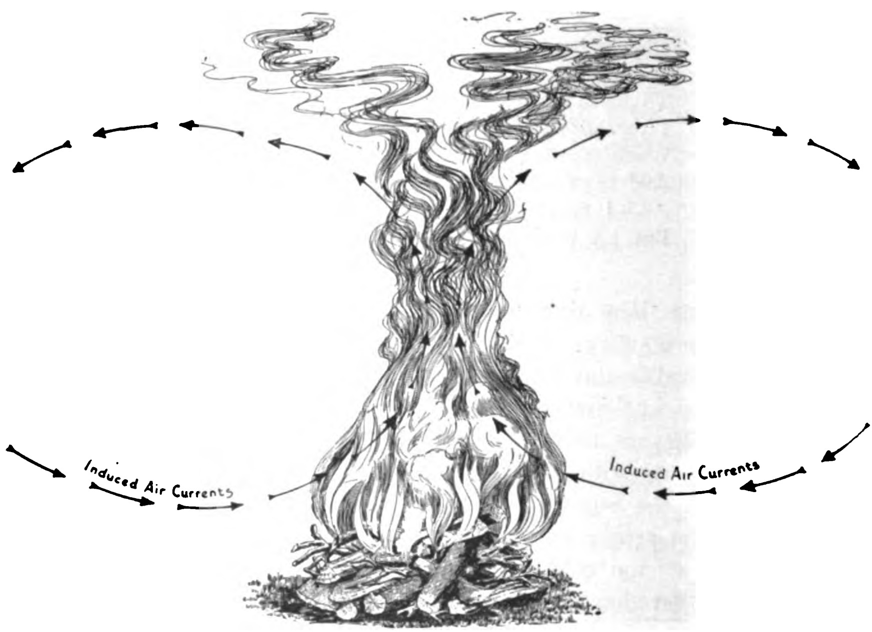

FIG. 9.—*How the wind blows.*

up the school-grounds. It may be that the weeds and grass have grown tall in the long summer vacation and you will need the help of a man with a mowing machine or a scythe. Gather into one big heap all the dead leaves, brush, grass and rubbish and when it is thoroughly dry it will make

a great bonfire. I want you to have a good big bonfire; so, if the school-grounds do not furnish enough material, bring in some brush and leaves from the neighboring fields until you have a pile six or eight feet high. Do not be in a hurry to light the fire. Let it dry several days and then choose a quiet day, when there is little or no wind blowing.

Before you start the fire, each boy and girl should have a handful of small scraps of thin paper (tissue paper is best), and one strip of paper about two feet long and one inch wide.

When everything is ready, form in a circle and light the fire. Now is the time to watch carefully everything that takes place. At first the smoke will rise from the fire slowly and then more rapidly. When the fire gets well started, you will see burning leaves rise with the smoke. Now, if you toss some of your scraps of paper toward the fire they will be caught and carried up also. When the fire is burning briskly, stand with your side to the fire and hold one of the strips of paper by one end in front of you and let the other end fall toward the ground. If the fire is strong enough the end near the ground will move toward the fire, which shows that the wind is blowing toward the fire. Now you have made the wind blow. Can you tell why it blows from all sides toward the fire and rises over the fire? If you can, you will know why all the winds of the world blow.

Let me help you a little. The fire heats the air over it, and when air is heated it expands and becomes lighter than cooler air and therefore rises, or more correctly is lifted or pushed up by the cooler air. If you take a little piece of wood and push it down to the bottom of a pail full of water and then suddenly let it go, you will see it rise to the top of the water very quickly. The piece of wood rises because it is lighter than the water. Heated air rises because it is lighter than cold air. The wind blows toward the fire because when the heated air rises there must be more air to take its place. The winds thus blow toward the warmest place.

Write your answers to these questions:

Why does the smoke go up the chimney?

What do you mean when you say "the stove draws?"

Why does the stove "draw?"

Why does the water come up out of the well when you work the pump handle?

POULTRY IN OCTOBER.

BY JAMES E. RICE.

October should be one of the busiest months of the year for the boy or girl who is taking care of poultry. It is one of the most pleasant months for working out-of-doors. We of the North seem to feel the hibernating instinct of a squirrel when fall comes. We enjoy "snugging up" when the days get shorter and the frosts remind us that winter is coming. We know from experience how good it feels to be snug and comfortable. The hens feel the same way. Notice how they seek the shelter of the bushes, fences, and buildings. They know full well that this is no time to lay eggs or to rear a brood of chickens. Therefore, they do what is perfectly natural and excusable, from the hen's view point,—they stop laying. Hens everywhere do the same; that is why eggs are always high-priced in October, November, and December.

Did it ever occur to you that hens begin to lay less about the last of June each year, when the days begin to get shorter, and that they naturally begin to lay again about the first of January, when the days commence to get longer? They do this because they know by the amount of daylight and sunshine when a more favorable or less favorable season is approaching. Hens lay well only when they are comfortable and happy. The happy, singing hen is the laying hen. That is why great care is necessary in the fall to get fowls into winter quarters early. There are many ways of doing this. One is to provide them with a nice, cheerful, cosy, clean house where they can be sheltered from the wind, where they can live in fresh air and have plenty of sunshine.

There are many things to be considered in making a home for hens. I say "home" instead of "house" because many expensive hen houses are not hen homes; they may look all right but they are too high or too dark or too damp or too dirty. A hen home should be low and dry and bright and clean, and have neat nests where the birds can hide their eggs. In fact, there are so many things to say on the subject of hen homes that it would take a whole book to describe them. You would better ask the College of Agriculture at Cornell University to send you Reading-Course Bulletin 33, which describes one way to build a hen home. Read it thoroughly and see whether you can make over your hen house into a hen home, if it is not one already. Do it now.

NATURE-STUDY CORNER. Figs. 10, 11, 12.

By Alice G. McCloskey.

Many schools last year had a Nature-Study Corner, a place in which nature-study materials were kept. In this corner was a table on which the children placed the different things of interest found in woods and along waysides, and which gave the teacher material for lessons. The subjects discussed were afterward used for compositions and frequently these compositions were sent to the University.

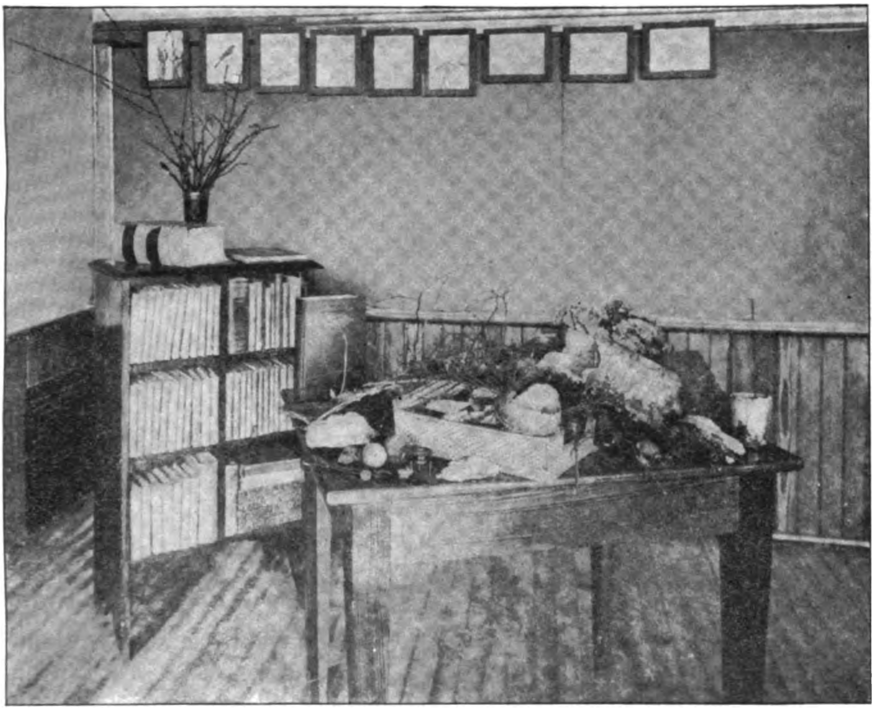

Fig. 10.—*A nature-study corner.*

This year we want you to have a Nature-Study Corner. I know of many that were in city schools and in rural schools. Perhaps this year some one in a rural school will be able to send us a photograph of a Nature-Study Corner. I am sure that boys and girls in farm districts can find more wonderful things to place on a Nature-Study table than those in the city. Let us see some of the things that might find their way there in October.

Bird homes.—How often we find in autumn a deserted bird home. This always makes an interesting nature-study lesson, for you can find out the remarkable way in which the nest is made and the materials used.

If you find a bird's nest to take to the school-room, be able to give your teacher information as to where you found it,—whether in a tree or on the ground. If in a tree, was it high or low? How was it concealed? Was it in the woods or in an orchard? For your lesson in the school-room find out the materials from which it was made. The bird's nest illustrated in Fig. 11 belonged to a red-winged blackbird and was found in a marshy place. I am sure that you will all think it a very attractive bird home, built as it was among the cat-tails and wild roses.

FIG. 11.—*Nest of red-winged blackbird.*

Wayside plants.—There are many wayside plants that you will find in blossom in October. Have one of each kind represented on the Nature-Study table. If members of the class will bring bottles to school and keep them filled with water, the blossoms of the wayside plants can be placed in them. Then the plants will keep fresh long enough for you to make a study of them. Often you will find a great many kinds of one plant group. Last fall I found twelve different kinds of golden-rod. There are also many kinds of asters. If your teacher will send for

the Home Nature-Study Course she will be able to help you in learning the differences in some of the fall blossoms that look very much alike.

Each child in the school should make a special study of a plant this year. The plant should be brought into the school-room and cared for until the school-house gets too cold. During the time the plants are there keep a record of them. They might be placed in the windows, or where they will get light, and they will thrive according to the care they receive.

FIG. 12.—*Plants grown by pupils.*

When the cold weather comes you might have a plant day, as a class did in one of our public schools. You could exhibit your plants in the Nature-Study Corner or have them on your desks and invite your parents to see them. It would be an interestingg exercise for each child to give a history of his plant from the first day he brought it into the school-room. Some plants will show improvement and some, I fear, may show neglect. If you have a plant day, let us hear about it.

LETTERS TO THE COLLEGE.

It is a good thing for boys and girls to write letters. Occasionally your teacher will ask you to write one for your language lesson, and I wish you would ask her to let you write to Uncle John Spencer about your nature-study work. We shall be glad to hear from you once every month, or oftener. We have promised to send a picture to every child who will write three good letters during the year. By a good letter we mean one in which you give an account of something out-of-doors that

you have actually observed. In order to be useful and successful in life, one must be a good observer. We want you to see things for yourselves, and to think about the things that you see.

We receive thousands of letters from children during the year, and we are very much pleased with the fact that more and more children are learning to write about things that they have found out themselves. Long ago we used to receive letters parts of which were copied from cyclopedias and other books. We do not care about such letters. We would rather have four or five lines giving the result of your own observation than to have four or five pages that you have learned from the observation of some one else.

Occasionally we publish letters in the Leaflet that we send to children. We hope to have many in these pages during this year so that our young readers may come to know the kind of letters that we care for. Read the following, and see whether you can tell why it was very acceptable to Uncle John:

ADDISON, N. Y., R. F. D. No. 2.

My Dear Uncle John:

My teacher said I could write to you instead of doing English. It is a very pleasant afternoon and the birds are singing gayly.

We are going to make a great improvement on our school ground. Our secretary will send you the drawing of the ground. He is my brother Lester. I also thank you for writing to my school-mate and telling him how to plant a tree for we intend to plant some trees here.

What kind of a fence do you think would be suitable for the ground? Two sides are fenced with an old rail fence, one side with a barb-wire fence. The fence is in a very bad condition and we have a neat little building and think it deserves a new fence. But we don't know whether we can get one or not.

We would like to have a garden very much but there is not room enough. We have a jar of willow twigs and among them are three different kinds, I think. One has a greenish yellow bark its bud covering has a reddish cast, one a blackish bark and the scales a black cast, I should call a blackish red color and its scales are black.

The bud on the greenish yellow twig is blossoming out. It is covered with golden dust. The one that has black scales and blackish bark wears its fur. And the other is covered with a light green fuzz.

Yours truly,

BESSIE MATTERSON.

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ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

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Lesson V.

THE STRUGGLE TO LIVE. Fig. 13.

By L. H. Bailey.

Object.—To lead the pupil to appreciate the great fact that every living thing is exposed to conditions or contingencies unfavorable to its wel-

Fig. 13.— *The struggle to live among the branches of a spruce tree.*

fare, and that it must contend with these conditions in order to live. This is the second generalization that any person should make when studying plants and animals.

Materials.—Any plant or animal anywhere; or a branch of any plant; or a leaf or bud of any plant.

The method is to study any plant, or branch of a plant, with reference to the position or condition under which it grows, and to compare one plant or branch with another. With animals, it is common knowledge that every animal is alert to avoid or escape danger, or to protect itself.

It is well to begin with any branch of any tree, as in Fig. 13. Note that no two parts are alike (Lesson 1, Leaflet No. 2 for October). Note that some are large and strong and that these stand farthest towards light and room. Some are very small and weak, barely able to live under the competition. Some have died. The pupil can easily determine which ones of the dead branches perished first. He should take note of the position or place of the branch on the tree, and determine whether the greater part of the dead twigs are toward the center of the tree top or towards the outside of it.

Let the pupil examine the top of any thick old apple tree, to see whether there is any struggle for existence and whether any limbs have perished.

If the pupil has access to a forest, let him determine why there are no branches on the trunks of the old trees.

A row of lettuce or other plants sown thick will soon show the competition between plants. Any fence row or weedy place will also show it. Why does the farmer destroy the weeds among the corn or potatoes?

Lesson VI.

A FIRST LESSON ON THE HORSE. Figs. 14 and 15.

BY M. W. HARPER.

"Round-hoofed, short-jointed, fetlocks shag and long,
Broad breast, full eyes, small head and nostril wide,
High crest, short ears, straight legs, and passing strong,
Thin mane, thick tail, broad buttocks, tender hide;
Look, what a horse should have, he doth not lack;
Save a proud rider on so proud a back."—*Shakespeare.*

Object of the lesson.—To direct the pupil's attention to the study of domestic animals and to give him an initial lesson in judging them.

Materials.—In all lessons in nature-study and agriculture, the pupil should study things first-hand. For this lesson on the horse it is important that he should have an opportunity to observe a horse. It may be that the class can be taken to a nearby farm, or, if in a village or city, to a stable. Possibly some boy in the class owns a horse which might be brought into the school yard for this lesson.

Since some of the good points of a horse are judged by proportion, the children may make an instrument for taking measurements, as follows: Secure a piece of soft white pine two inches wide, one-half inch thick, and four feet long; to one end of this, and at right angles to it, tack securely a similar piece of pine 18 inches long; to the other end strap loosely an ordinary carpenter's square, so that it may slide back and forth. Now mark off the long piece in inch and half inch lengths, beginning at the inside of the stationary bar. A yard stick may be used for making the measurements but to have them accurate the instrument should be made.

Every farm boy, and every girl, too, for that matter, should know what characters constitute a good horse,—what makes a horse wanting in form, what makes it desirable. The organs of animals when studied in detail exhibit dimensions of length, breadth, thickness, and direction. It is, in part, on account of these general relations, or proportions, that we distinguish, at first sight, a horse from a zebra. These proportions may be good or bad. If good, the animal is said to be well formed or has a handsome form; whereas if bad, he is said to be wanting in form, or not beautiful.

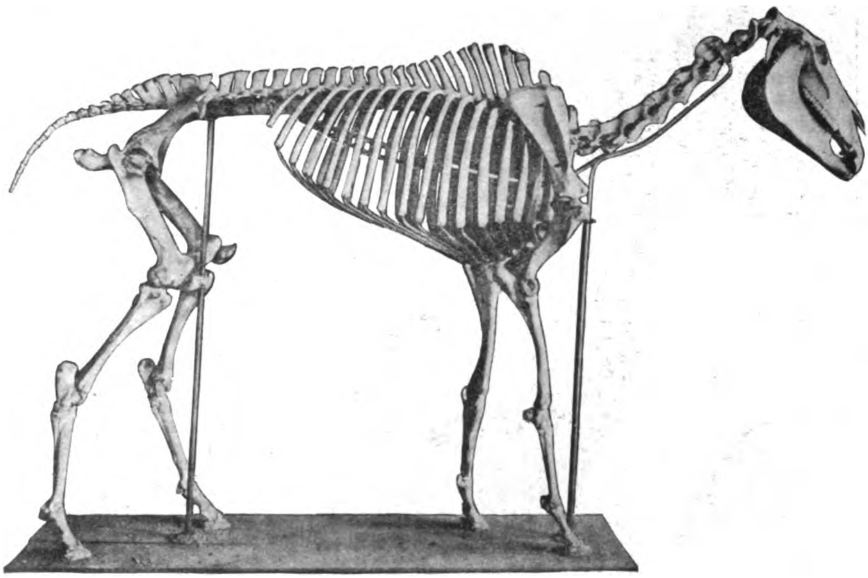

FIG. 14.—*Skeleton of a horse showing frame-work to which are attached the tendons, cartilages and muscles.*

In a study of these relationships or proportions, we must take some organ as a unit or standard of measurement. The head of the horse is the part most used for this purpose, because it is the most noticeable, its length is easily obtained, and variations are more rare than in other organs or parts.

If we take the total length of the horse's head, from the tip of the lips to the top of the poll, and compare it with the body of a well-formed horse, we will find that there are four other measurements almost exactly equal to it as follows:

(1) The length of the neck, from the top of the withers to the poll. If there is much difference between these measurements, we say the head is too long or the neck is too short.

(2) The height of the shoulder, from the top of the withers to the point of the elbow.

(3) The thickness of the body, from the middle of the abdomen to the middle of the back.

(4) The width of the body, from one side to the other. If there is a great variation in these measurements, we say the horse has a poor form.

FIG. 15—*A well proportioned horse; a, poll; b, lips; c, withers or shoulder lops; d, point of elbow; e, chest; f, back; g, abdomen; h hips; j, rump; k, buttock; l, knee; m, fetlock joint.*

Note. *The above lesson, although very simple, deals with actual things. It is, therefore, worth the while in the teaching of nature-study. If the pupils really take part in this lesson, they will adways note the proportions of a good horse.*

Please ask the pupils to write to us on this subject. We would like to know how many classes in New York State have had an opportunity to do a really useful piece of work in animal husbandry.

In this lesson the facts are given for the benefit of the teacher. The pupils should learn these facts from their own observations, directed by the teacher. They should make the above measurements. Other lessons on the horse will follow.

Lesson VII.

STUDY OF THE ROOTS OF LEGUMES. Figs. 16, 17, and 18.

BY G. F. WARREN.

Object.—To continue the study of the pea family (begun in the preceding Leaflet) and, specifically, to study the nodules on the roots of legumes.

Materials.—A spade and growing plants of the kinds mentioned below.

If the lesson in the last number of the Leaflet on learning to recognize legumes has not been given, it should be given before this lesson.

I.

Conduct the class to the school yard or to a field and dig up as many kinds of legumes as possible. This work can be given at any time until the ground freezes too hard for digging. Almost any roadside will furnish an assortment of legumes.

Examine as many of the following as possible: red clover, white clover, sweet clover, beans, peas, alfalfa.

Examine the roots of clover for small white nodules or tubercles about twice the size of a pinhead, Fig. 16. Those on other clovers and on alfalfa are also small. Those on beans are about half as large as a pea seed, Fig. 17.

What is the shape of the nodules on each kind of plant?

Make a drawing of the roots of several plants showing different kinds of nodules.

Dig up some grasses and other kinds of plants and try to find nodules.

The teacher should explain the nature and value of the nodules. (See part IV.)

II.

Ask the students to bring to school as many other kinds of legume roots as they can find, so that the other members of the school can see them.

It is possible to conduct the entire lesson on materials brought in by students, but it is better to begin with a field trip.

Are alfalfa or soy beans grown in the neighborhood?

If so, has the soil been inoculated with soil from any old field? Why was this done?

The best specimens found may be preserved in the school room. They will arouse interest on the part of patrons who visit the school.

FIG. 16.—*Nodules on the roots of red clover.*

To preserve them, place the roots in a wide mouth bottle or fruit jar, and fill with 96 parts of water and four parts of formalin. Then seal tightly. If well sealed, they should keep permanently. Do not forget to label them. A few ounces of formalin may be secured at a drug store. Other materials may be preserved in the same way.

IV

Bacteria are microscopic plants. There are many kinds of them. One kind causes typhoid fever and another causes tuberculosis (consumption). But the great majority are either harmless or helpful to mankind.

Certain kinds of these bacteria in the soil are good friends to the farmer. One kind lives on the roots of legumes and causes the nodules or tubercles. In some way these bacteria take nitrogen from the air so that it becomes available for the growth of plants.

The larger part of the air is nitrogen, but no plants can take nitrogen from the air. They can only use it when it is combined with other things. The air between the particles of the soil furnishes the nitrogen for the bacteria on the legumes. These bacteria do not live on the roots of any common plants except legumes.

The reason why this is os important a subject is because nitrogen is the most expensive thing that farmers buy in fertilizers. They now pay about 21 cents per pound for the amount of actual nitrogen in a fertilizer.

Sometimes the bacteria are not in the soil, so that the legumes do not have the tubercles.

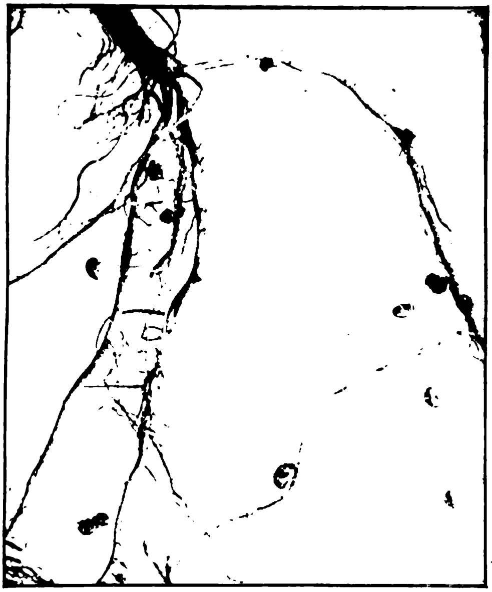

FIG. 17.— *Nodules on the roots of a bean. Compare with clover and vetch.*

Only when a new kind of a legume is introduced are the bacteria likely to be lacking. The majority of the soils in New York need to be inoculated for alfalfa when it is first grown and so far as we know all soils in the State need to be inoculated for soy beans. The best means of inoculation is to take soil from a field where the crop is inoculated and scatter on the new land. About 200 lbs. of such soil is enough for an acre. Sweet clover soil inoculates alfalfa so that where sweet clover is plentiful, alfalfa does not often need to be inoculated.

If any teacher desires to try a simple experiment in growing alfalfa in the school garden with different methods of treatment, we will be glad to furnish information on the work. Bulletin 221 of the Cornell Experiment Station, on alfalfa, will be sent on application.

Words to be spelled and defined.

Nodule, a little knot or lump.

Tubercle, a nodule formed within a plant or animal by bacteria.

Bacteria, microscopic plants often called microbes.

Microscopic, too small to be seen without a microscope.

Nitrogen, a gas that constitutes about four-fifths of the air.

Fertilizer, a material for making land more productive.

Inoculation, infection with bacteria or some other organism. As inoculation with small pox virus, or the adding of certain bactria to a soil.

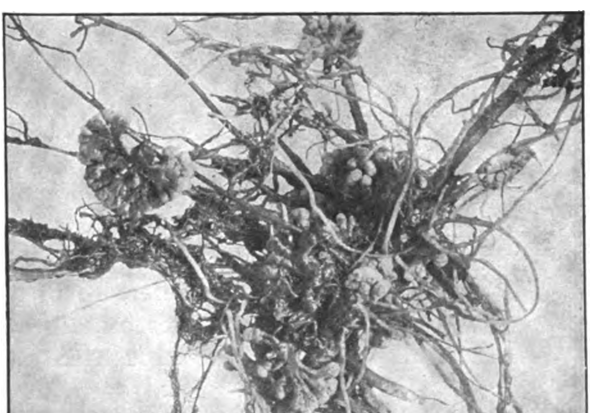

FIG. 18.— *Nodules on the roots of hairy vetch. Compare their size and shape with clover and bean.*

Lesson VIII.

A STUDY IN FRUITS. Figs. 19, and 20.

By C. S. WILSON.

Object.—To teach the structure and classes of our common fruits.

Materials.—Each pupil should be supplied with two apples, two pears, and a few peach pits; also a quince and some plum pits if possible; one drawing pencil; one knife.

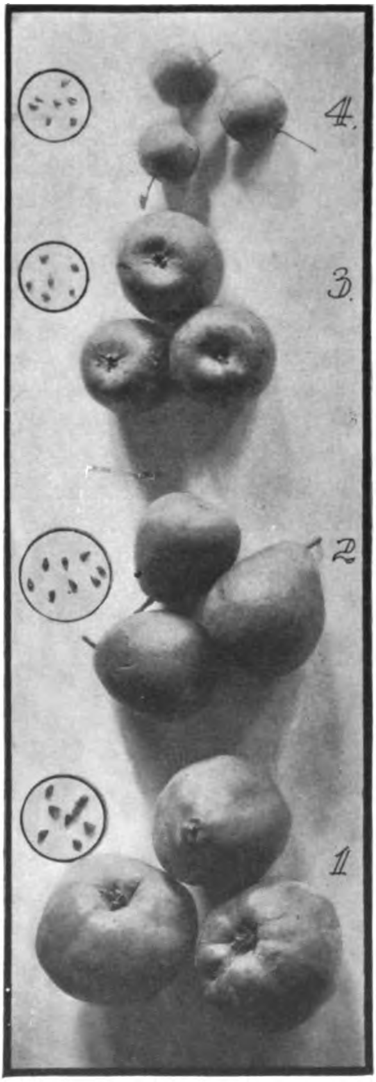

FIG. 19.—*The fruit and seeds of our common pomes. 1, Quinces; 2, Pear; 3, Apple; 4, Crab.*

For the general use of the class, the school should have a shovel, two gardener's "flats," which are shallow boxes and which can be made by the boys from soap boxes, and sufficient sand to fill the flats.

First, let each pupil take an apple and a pear, and observe the blossom end opposite the stem. Here is a clearly defined depression which is called the basin. Recall the blossom end of the peach and plum. Is it the same as that of the apple and pear? How does it differ? Examine the calyx-lobes in the basin of the apple and pear. These lobes are the green covering of the bud before the flower opened. Note the number.

Second, let each pupil cut the fruits through the center in a plane perpendicular to the main axis. Note the space which the core occupies. Examine the core, the cells, and the seeds. Observe the number of cells. There are five, the same as the number of calyx-lobes. Note their position in reference to the calyx-lobes. A cell lies beneath each lobe. A cut made through the end of one of the lobes and down through the main axis of an apple passes through the center of a cell. Observe the parchment-like

walls of the cell. They are called carpels. Note the number of seeds in each cell. This number will vary with different fruits and different varieties of the same fruits. In the apple two are usual, rarely three or more. Sometimes no seeds develop. Save the seeds.

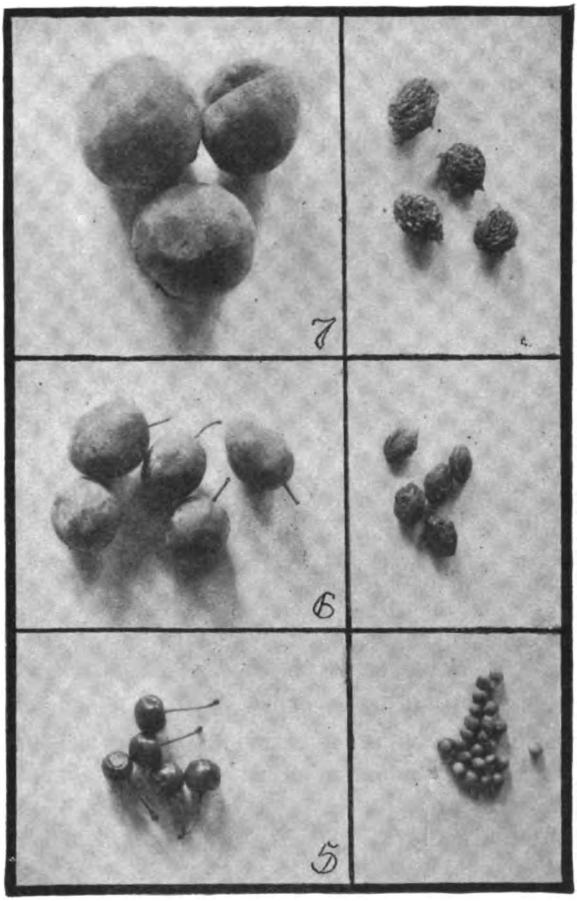

FIG. 20.— *The fruit and pits of our common drupes. 5, Cherry; 6, Plum; 7, Peach.*

Third, compare the structure of the plum pits or peach pits and the apple seeds. Note the rough, hard shell-like covering of the pit or stone. The seeds have a smooth, tough covering not as thick as that of the pits, yet thicker and tougher than that of vegetable seeds. Observe the meaty portions of the pits and seeds. In this meaty portion lies the embryo which, under proper conditions of moisture, heat, and oxygen, will grow into a new plant.

Application of the observations.—These fruits belong to two groups or classes of fruits—the two classes which comprise our common tree fruits. Determine whether the pupil can properly classify these fruits from the observations already made.

Class 1.—Pomaceous fruits, called pomes (members of the genus Pyrus) or seed fruits:

Apple,
Pear.

(Ask the pupils to name the other two common fruits belonging to this class.)

Crab apple,
Quince.

Class 2.—Drupaceous or stone fruits, called drupes (members of the genus Prunus):

Plum,
Peach.

(Ask the pupils to name another common fruit belonging to this class.)

Cherry.

Drawings:

1. Make a drawing of the cross-section of the apple showing
   (a) The skin,
   (b) The flesh,
   (c) The carpels,
   (d) The cells of the core,
   (e) The seeds.

Answer the following questions:

1. What fruits have a depression at the blossom end?
2. What is this depression called?
3. What fruits are more or less round at the blossom end?
4. What is the calyx?
5. How many lobes has it?
6. What four common fruits have seeds?
7. What three common fruits have pits?
8. How much space does the core take up in an apple?
9. Would the apple be worth more if the core were larger or smaller? Why?
10. How many cells in the core of an apple?
11. What are the carpels?
12. How do pits and seeds differ in structure?
13. To how many classes do the common tree fruits belong? Name them.

14. What fruits belong to the pomes?
15. What fruits belong to the drupes?
16. What are the general differences between a pome and a drupe?

THE BABCOCK TEST.

The Babcock test provides a quick and accurate method of showing the richness of milk, which means its percentage of fat. Next month we shall publish a lesson by Professor Pearson, giving instruction for making the Babcock test. This is a lesson that should be given in every dairy community, in fact in every farm community. Aside from its practical value to the farm boy, it has broad educational value.

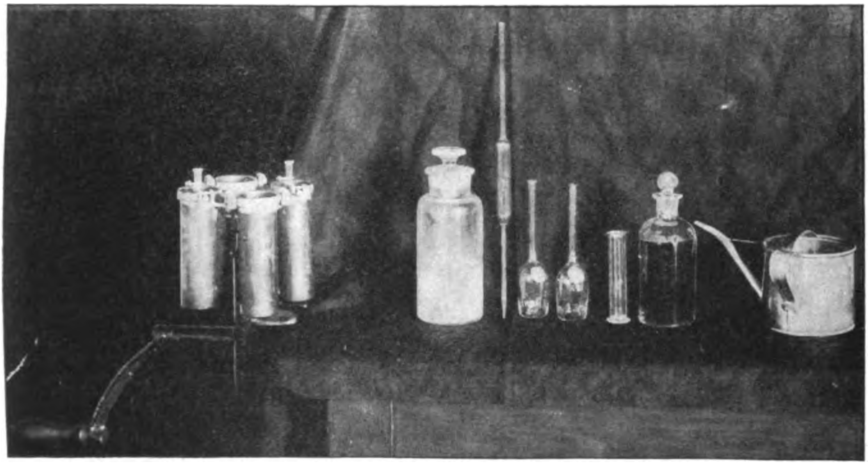

FIG. 21.—*Apparatus for the Babcock test.*

The articles shown in the picture are, from the left; Centrifugal machine for four bottles, two of the cups having milk test bottles in them. Sample of milk. Milk pipette which holds 17.6oc. Two milk test bottles. Acid measure. Sulphuric acid. Hot water.

Before giving this lesson on the Babcock test, we would like to send an apparatus for making it to one school in each of ten counties, this apparatus to be used and returned to us in two months. Therefore, we shall send the complete outfit for making the Babcock test to the first ten rural school teachers in ten different counties making application for it. Here is an opportunity for the rural school teacher to make his work felt in his community. If some of the older pupils are able to handle this test and give a demonstration of it at some of the school meetings or farmers' meetings, it may be the means of interesting farmers to help their children to get better agricultural instruction. This present Leaflet is sent out to all teachers on our lists the same day. We shall consider the first application from each of ten different counties.

Some teachers in rural communities have already provided them-

selves with apparatus for making the Babcock test, and have had excellent results. Following is an extract from a letter written by Mr. H. H. Lyon, of Bainbridge, N. Y.:

"Working the Babcock test in our rural school was of use to us in several ways: In the first place, it enabled us to find out the relative value of several samples of milk produced by various cows owned in our neighborhood. Then it gave our pupils quite a bit of drill in accurate measurements. It also afforded a basis for a number of interesting problems in arithmetic, and a splendid subject for compositions, especially after the pupils had made the tests and taken the measurements themselves. Finally, it helped very much to give an insight into the border land of science, and assisted in broadening the pupils' views.

"We went about it in this way: First, the bottles were examined, so that each pupil understood the workings on the necks of the bottles. Then the bottles were filled up pretty well into the neck with clear water, and some oil from a bicycle oiler was added above the water. The bottles were then passed and each pupil made a 'reading' of the oil, and noted the results, with its proper number, on a slip of paper. Later these readings were compared and tabulated, and an opportunity was given for those who desired to do so, to correct their readings.

"A later lesson consisted of a practice exercise in measuring with the pipette. Water again being used. It required some time to become accurate in measurements; and to make sure of the correctness, several measurements were taken by each pupil and let run into a graduated glass. The total measurements in the glass should equal the sum of the successive measurements with the pipette. Measuring the acid with a graduate was watched very carefully, so as to avoid any accidents. After some degree of proficiency in measuring had been acquired, the somewhat amusing experiment of transferring water from the pipette into the test bottle had to be made. Those narrow mouths have a way of choking up pretty easily.

"A little experimenting with the machine had to be done to secure proper speed. Different pupils turned it while others held watches and counted. After all this preliminary work, a real test was made, using milk. The result was surprisingly accurate, and the readings were made by different pupils with only slight variations, in most cases. Of course, it took several days to accomplish the whole work, since only a short time could be allotted to it on any one day. One of the best parts was cleaning up the bottles and apparatus after the experiment had been completed. The best pupils do not leave such work for someone else to do.

"A good many problems in percentage were worked out as a result of this test, also some in fractions. A very good advance was also made in understanding the metric system of measurements, and in the case of some of the older pupils, problems involving specific gravity were introduced."

CORNELL

Rural School Leaflet

SUPPLEMENT FOR THE CHILDERN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. I. ITHACA, N. Y., NOVEMBER, 1907. No. 3

THE NATURE-STUDY CORNER.

There are so many interesting things to be found out-of-doors in November for the nature-study corner, that it is difficult to select one subject for special observation. When the leaves have fallen from the trees and wayside plants, many things are exposed to view that were hidden in the summer. Out-door folk have many enemies and so they try to hide their dwelling places and store-houses. In fall and winter, however, very strange homes are often exposed and naturalists make most interesting discoveries.

As you walk along the road-sides you will probably notice what children call little "bunches" on the golden-rod stems. We are often asked what there are, and why they are there. To the naturalist the bunches are known as galls, and they are the homes of insects. You will be interested to learn something about the lives of the little creatures that live in them.

There are two very noticeable galls on the golden-rod stems: one, elongated or spindle-shaped; the other, round. In this lesson I shall speak of the spindle-shaped gall, for having learned the history of this one, you will probably be interested to find out the story of the other yourselves.

FIG. 22.—*The golden-rod gall.*

Before you can understand the history of the little inhabitant of the golden-rod gall, you must know that there are four periods in the lives of many insects; that is, four periods in each of which the insect appears in a different form. The moths have these four periods, and the insect

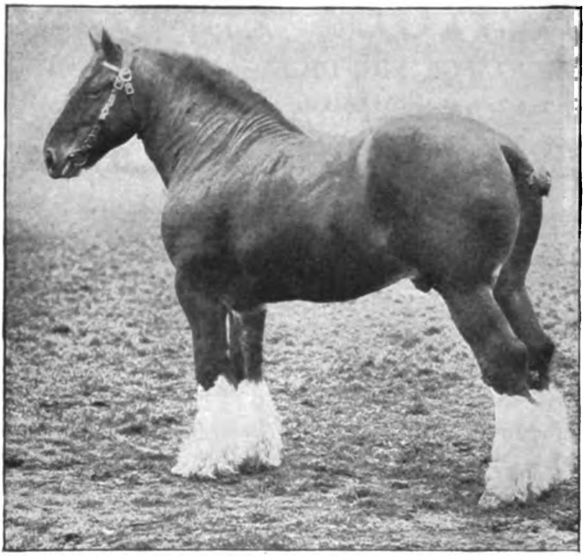

FIG. 23.—*A typical draft horse. For what purposes are draft horses used?*

that spends part of its life in the spindle-shaped gall on the golden-rod is a moth. The four periods are: the egg; the caterpillar or larva which hatches from the egg; the pupa or inactive state; and the moth.

Now briefly told, the life of the little moth is this: The mother moth lays an egg on the golden-rod stem, and from this egg there hatches a little caterpillar. Then the stem grows into a spindle-shaped green house making a nursery and a store-house for this small creature. There it eats, grows larger, and finally changes to a pupa when it is enclosed in a little case and does not move about. It does not leave the little case until it is a fully grown moth prepared by fly out over the fields.

But how does the moth get out of the gall, you will ask? Preparation was made for this when the insect was a caterpillar. The small moth has not strong mouth parts that it can use to work its way out of the house that surrounds it, therefore, when it is a caterpillar it eats a hole to the surface of the gall. It would not do to leave this door-way open, for a bird or some other enemy might reach it, so the larva makes a plug of silk shaped like a cork. No enemy can push the plug in but when the little insect becomes a moth it can push it out. Notice whether the spindle-shaped gall has a hole or whether there is a plug in it. As soon as you have found this out you will know whether the insect is inside.

The round gall on the golden-rod is not made by a moth. Find out whether at this season of the year there is a hole through the gall by means of which the insect has escaped. If not, perhaps the insect is inside. See whether you can find out.

Road *Outdoor Studies* by James G. Needham.

ABOUT HORSES.

Each month we are going to learn something new by studying real things. This month we have asked the older boys and girls to study some of the points of a good horse by means of measurements. If this is done in the schoolyard or at some farm near, perhaps the teacher will let you watch the older children make the measurements.

We also want you to make some observations for yourselves. All boys and girls can see horses. You may have an opportunity to observe one at home, or if not, there will be the horses that pass the schoolhouse: the butcher's horse, the baker's horse, and many others.

Write a letter this month about horses. The following questions may suggest to you lines of observation that we would like to have you make. You cannot find the answers of these questions in books. You may not be able to answer all of the questions but if you answer two or three from your own observation, we shall be satisfied.

1. Where is the horse's knee joint? Which way does the knee bend?
2. Where is the hock joint? Which way does it bend?
3. Can a horse sleep when standing?
4. How are the legs placed, when a horse lies down?
5. How does a horse get up,— front legs first or hind legs first? How does a cow get up?
6. When a horse starts, after standing, what foot does he put forward first,— the left or the right? Fore or back? What foot moves next?
7. When a horse trots, do the two feet on one side move together? Or do lefts and rights move together?
8. What does a driver mean when he says that a horse "forges" or "over-reaches"?
9. Name the things that a horse commonly eats. What is a good feed for a day,— how much of each thing and when given?

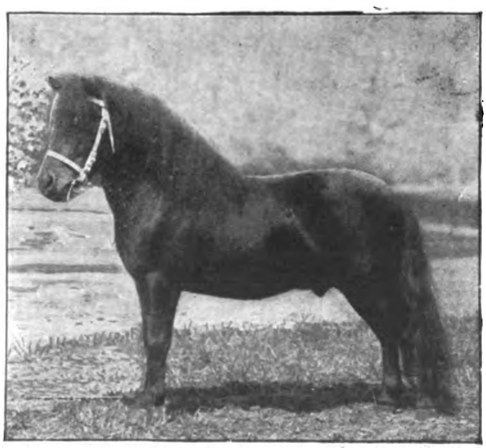

FIG. 24.—*Shetland pony. How does it differ from other horses?*

When we consider how much horses do for us, I think we should be as thoughtful for them as possible. If you have a horse at home, I wish you would note the following:

1. Whether his harness fits so that no galls or sores may be caused by the rubbing of collar or straps.

2. Are the bits kept clean and free from rust?

3. Do you warm the bits in frosty weather? Why?

4. If your horse wears a check-rein, it should be unhooked when he is pulling a load up hill. Why?

5. Notice whether his coat is well curried and brushed. A well kept coat is not only more attractive, but the animal's condition depends much upon its care.

CHILDRENS' LETTERS.

The following letter was selected for publication this month. You will notice that Gladys does not speak of things she has read but of things she has seen.

Uncle John:

One day we heard a bird making a noise that we had never heard, and we ran out to see what kind of a bird it was. We told our neighbor, and she came out and told us that her folks always called it a flicker. Then I remember that you talked about a bird called a flicker in the June number. Its back was gray, with black stripes and a red patch on its head. We did not see its breast, and it was a great deal larger than a robin. Was it a flicker?

As papa was plowing one day the horses nearly stepped on a meadow lark's nest. The little birds were already hatched, and papa lifted up the nest, which was made out of grass, and put it over in another place where he was not plowing, and covered it with grass and cornstalks. At noon when he went back to the field the little birds had their mouths open crying for food, and papa thought the old bird had not been back, so he found some cut worms and they ate them.

One day papa saw some field mice, and their nest was made out of the silk of the milkweed plant. Their back was gray and they had long tails. Underneath of their bodies was white.

I was riding along the road yesterday, and over in the field I saw a ground hog. It stayed there about three minutes and then went down in its hole, I think. Papa said that they were all over the field. It was about the color of a Belgian hare. I was told that they had hair like the bristles of a hog. It was sitting up on its hind legs, and did not seem a bit afraid

Yours truly,

GLADYS.

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Lesson X

PLANTS AND ANIMALS BECOME ADAPTED TO THE CONDITIONS IN WHICH THEY LIVE.

By L. H. Bailey.

Object.— To show that all living things are suited to their surround-

Fig. 25.—*It is December.*

ings and to lead the pupil to understand that this adaptation is necessary to the continuation of life on the globe.

The material for study is any plant or animals anywhere; for, if all

plants and animals are thus fitted or adapted, we should be able to see the evidence of it in the first plant or animal that we meet.

The method is to educate the mind to comprehend what is before it,—to train the pupil to see what he looks at.

The pupil must first understand what is meant by the "conditions" under which plants and animals live. There are four main classes of conditions, at least for plants: (1) the climate and seasons; (2) the soil; (3) the mere crowding or contest with each other; (4) the danger from organisms that injure them or feed on them.

For the present, we may consider some of the ways in which plants adapt themselves to climate and the seasons. It is December. The elms and maples are bare. The leaves are dead, and they have drifted into corners and hollows. The twigs are no longer green and growing. The buds are packed away in dense coverings of close-fitting scales. Last July, all was different. If hard frost had come then, the trees would have been killed. The trees are adapted to the cold? How do you suppose the palm trees and others in the tropics behave?

Trees are adapted to the winter by ceasing to grow, by reducing their juices to the smallest amount, by casting off the tender organs, and by hardening their parts. They store their food and energies in such form in twig and branch that freezing does not injure. Some trees (which ones?) hold their green leaves, but if we were to examine these leaves minutely we should find that changes have taken place in their cells to enable them to survive the frost.

Some plants die outright at the approach of winter, and they perpetuate their kind only by means of seeds. Name some of them. Others are carried over the winter by means of bulbs and tubers; what ones?

Other plants die to the ground, and only the underground parts survive. Name them. Do the leaves that fall from the trees aid any plants to survive the winter?

Animals are adapted or related to our climate (1) by changing their region; (2) by hibernating; (3) by such hardiness of constitution that they endure the cold. Name examples in these classes.

Adaptation is not always perfect or complete. Very hard winters may kill or injure some of the bushes and trees. Among both plants and animals, the least adapted soon perish and the best adapted live and thrive.

Lesson XI.

THE BABCOCK TEST FOR BUTTER-FAT IN MILK.

BY R. A. PEARSON.

Object.— To become familiar with a quick and accurate method of showing the richness of milk, which means its percentage of fat.

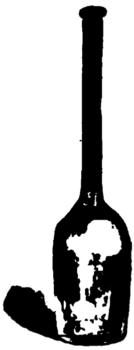

FIG. 26.—*Test bottle.*

Utensils.— A hand-power centrifugal tester, at least two milk test-bottles (Fig. 26), one pipette to measure the milk (Fig. 27), one acid measure (Fig. 28), about one pint of sulfuric acid with specific gravity between 1.82 and 1.83, a few ounces of milk, and some hot water. All the necessary apparatus and acid can be purchased for about five dollars from any dairy supply company. They can be ordered through a hardware dealer. Sulfuric acid is sold also at drug stores.

Sampling the milk.— The milk to be tested should be thoroughly mixed just before the sample is taken, to make sure that the fat or cream is evenly distributed. This can best be done by gently pouring back and forth between two vessels several times. The milk should be neither very cold nor hot.

Place the small end of the pipette at the center of the milk and suck the milk up above the 17.6 cc mark. Quickly put the index finger over the upper end of the pipette and by releasing the pressure allow the milk to run out until its upper surface is even with 17.6 cc mark when the pipette is held straight up and down.

Place the point of the pipette a short distance into the test-bottle neck, holding it against the glass and with both pipette and bottle at an angle (Fig. 29). Remove the finger to allow the milk to flow into the bottle. Be sure to get every drop of the milk, taking care to drain the pipette and to blow the last drop into the bottle. A little practice should make anyone proficient with the pipette.

FIG. 27.—*Pipette or milk measure.*

It is best always to make this test in duplicate; hence two bottles are needed for each lot of milk.

FIG. 28.—*Acid measure.*

Using the acid.— The acid is very strong and must be handled with great care. If any gets on the hands, face or clothing, it should be washed off quickly and water should always be ready for this purpose. *Do not leave the acid where young children can get it.*

FIG. 29.—*Putting the milk into the test bottle. The pipette is held at an angle with the test bottle and its point against the inside of the neck.*

After all the samples of milk to be tested have been measured, the acid should be added. Fill the acid measure to the 17.5 cc mark with acid that is neither very cold nor hot. Pour this into the bottle with the milk, holding the bottle in a slanting position. The acid will then carry down any milk left in the neck and follow the glass surface to the bottom of the bottle and form a layer under the milk.

Hold the bottle by the neck and give it a circular motion for a few minutes, mixing the milk and acid until no milk or clear acid is visible (Fig 30). By this time the contents will be dark colored and hot. This change is due to the acid dissolving all the solid constitutents of the milk except the fat, which it does not affect.

FIG. 30.—*Mixing milk and acid. A rotary motion with the bottle not pointed toward the face.*

Whirling the bottles.— The bottles are whirled to separate the fat so that it can be measured. They should be hot when whirled. If necessary they may be heated by standing in hot water before being put into the machine. A steam machine is easily kept hot when in use. Other kinds should have boiling hot water placed in them.

Place the bottles in the machine so that each one will have another directly opposite, to keep the machine in balance. Whirl the bottles five minutes at the proper speed for the machine in use (Fig. 31). Then stop it and, with the pipette or other convenient means, add hot water to each bottle until the contents come up to the bottom of the neck. Whirl two minutes. Add hot water enough to bring the top of the fat nearly to the top of the graduations on the neck of the bottles. Whirl one minute. The fat should then form a clear column in the neck of the bottle.

FIG. 31.—*Whirling the samples.*

Reading the percentage.— Keep the fat warm so that it will be in a fluid condition. Hold the bottle by the upper end of the neck, letting it hang in a perpendicular position, on the level with the eye. Read the mark or graduations at the extreme top and bottom of the fat column. The difference between these is the percentage of fat in the milk.

Most test-bottles are made to read as high as 10 per cent. Each percentage has its number marked on the glass and there are five small spaces each representing .2 per cent between these principal marks. Thus, if the top of the fat column is even with the third short mark above the 7 mark, the top reading would be 7.6; and if the bottom is half way between the first and second short marks above the 3 mark, the bottom reading would be 3.3; the difference is 4.3 which is the percentage of fat or number of pounds of fat in 100 pounds of milk tested.

Notes.—

1 cc means 1 cubic centimeter or about 20 drops.

If the fat column is clouded with white specks, probably the acid was not strong enough, or not enough was used, or the heat was not high enough.

If the fat column is clouded with dark specks, probably the acid was too strong, or too much was used, or the heat was too great.

Always keep the acid bottle closed when not in use or the acid will lose strength. *Remember that it is a poison and corrosive.*

Lesson XII.

EGG TYPES.

BY JAMES E. RICE.

Purpose of the lesson.— To train the pupil's power of observation, especially in his ability to recognize differences in size, weight, form, color, and texture of eggs; to familiarize him with the characteristic types of eggs that are laid by the different species, classes, breeds, and varieties of domestic poultry; to note variations from the normal eggs, and to lead the pupil to inquire into the causes for those that are abnormal; to afford the pupil training in accuracy of expression in the words used to describe the various forms, colors, and textures of eggs.

Materials.— (1) A collection of eggs from as many different kinds of poultry as it is possible to procure. Eggs from the domestic fowl, ducks, geese, turkeys, guineas, pheasants, pea fowl, pigeon, quail, etc., and also from many different breeds and varieties of each of these kinds of poultry. (2) One or two insect cases. (Fig. 33.) If insect cases can not be secured, a neat box that can be covered tightly will do. (3) Several egg drills and blow pipes. These instruments are not very expensive. They can be purchased at Ward's Natural Science Establishment, Rochester, N. Y., for twenty-five cents each. I have known young persons, however, who could blow the contents from an egg shell with a straw without the aid of drills or blow pipes. (4) Pot of glue. (5) Labels as shown in Fig. 32. (6) Drawing paper. (7) drawing pencils. (8) Lead eraser. (9)

Color crayons or water colors to be used when pupils have had sufficient training in color work. (10) One pair of balances or scales.

The collection of eggs can be made permanent by blowing the contents from each egg and mounting the shell on a wooden block. (Fig. 32). These mounted eggs can then be arranged in an incest case, (Fig. 33) each egg properly labeled as follows: Species; Breed; Variety; Date; Name of breeder; Pupil who prepared the specimen.

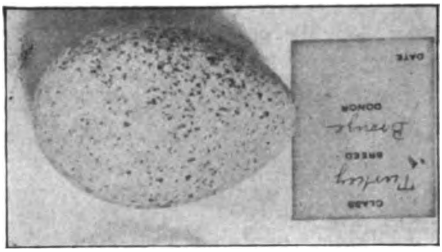

FIG. 32.—*A specimen for the egg collection.*

In this form the egg shells may be safely kept in the school-room where they make an attractive and instructive collection for general observation when not desired for class instruction. From time to time pupils will be able to add to the collection. When eggs are brought in from the poultry house to be used in the home for cooking, perhaps the contents of some of the eggs can be blown out, and the shells added to the collection. They should always be properly labeled.

Methods of presentation.—

(a) The size, weight and form of eggs.

Make an outline drawing, natural size, of as many different kinds of eggs as the time will permit. Place several eggs representing different types side by side and observe the different outlines.

Select one dozen eggs each of large, medium, and small sizes. Weigh them and estimate the loss or gain if they had been purchased by weight instead of by the dozen. A dozen's hen's eggs should weight 1½ pounds or 24 ounces, equal to two ounces each.

Describe the different forms of the eggs by suitable descriptive terms, as elliptical, round, elongated, egg-shaped, etc.

Place the eggs of different sizes side by side and note how, by the law of contrast, the small eggs look smaller when compared with the large eggs than they do if seen in a group by themselves. *It pays to produce eggs of uniform size and shape, and to grade eggs carefully before marketing them.*

(b) Color of eggs.

Compare the variations in color of the different collections of the different kinds of eggs. Represent these by giving the proper tint to the eggs already drawn in outline.

Arrange the dark-colored and light-colored eggs in such a manner that there shall be a perfect gradation and blending of colors from the darkest brown to the pure white. Note the great contrast in color when

the brownest and whitest eggs are placed side by side. Group the tinted eggs together and note how much darker the light brown eggs appear when placed by the side of the white eggs than they do when placed by the side of the brown eggs. Note also how much darker the whitish eggs appear when contrasted with the pure white eggs than they do when seen by the side of the light brown eggs.

FIG. 33.—*A collection of eggs for study.*

Observe how much more attractive a dozen pure white eggs and a similar number of brown eggs appear when grouped alone than they do when mixed together. *It pays to produce eggs that are uniform in color.*

(c) Texture of eggs.

Note the differences in texture of the egg shells from the different kinds of poultry,— the glossy, the smooth, the rough, the thick, and the thin shells. The differences in texture of the shell are usually breed characteristics and may be used to determine the kind of fowl that laid the egg. Sometimes fowls lay eggs which have abnormal shells because

there is a deficiency in lime due to improper feeding. In this case the eggs are not likely to hatch well or to produce strong chickens if they should hatch. Only eggs that are perfect in size, shape, color, and texture which is characteristic of the breed should be used for hatching purposes. *A hen is likely to produce eggs which in every respect are similar to the egg from which she herself was hatched.*

(d) The kinds of eggs laid by the different species, breeds, and varieties.

Cover the label which tells the kind of fowl which laid the egg and give each egg a number.

Hand each pupil a paper on which to write the number of each egg and the name of the fowl that laid it. The papers can then be corrected by permitting the pupils to exchange papers and mark "correct" or "incorrect" as the teacher holds up the egg to the class and gives the name of the fowl that laid it.

Lesson XIII.

PLANT-FOOD.

G. F. WARREN.

Object.— To give a preparatory lesson so that the class will be able to understand questions about food for plants, animals, and man. In succeeding lessons the relationship to legumes will be shown.

Points in this lesson must necessarily be told to the pupils by the teacher. It is, perhaps, a little difficult, but just this kind of information is commonly discussed by farmers, and is of great importance in their business.

By chemical analyses, it has been found that all the different substances in the world can be separated into about seventy different things. These are called *elements,* because no chemist has ever been able further to separate them. Carbon, hydrogen, oxygen, nitrogen, sulfur, gold, silver, copper, tin, and lead are all elements. For example, gold cannot be separated into anything but gold, neither can any two or more things be united to make gold. For centuries men have tired to make gold of other things, but they have always failed. Water is not an element. It is formed of the union of elements. It is a *compound.* A chemist can easily separate water into two gases, hydrogen and oxygen, and when the gas hydrogen burns, water is formed. Likewise, carbon dioxid can be separated into carbon and oxygen; and when the carbon in coal or wood burns, it forms carbon dioxid (carbonic acid gas). Similarly when we breathe, the carbon of our bodies unites with the oxygen which we breathe and carbon dioxid is formed. Soot is nearly pure carbon that was cooled and so prevented making a union with oxygen.

Carbon dioxid does not look anything like carbon nor is hydrogen anything like water. The only way that we can tell that water is com-

posed of these two gases is because the gases have been combined and formed water and because water has so often been separated into the two gases. Any such substance is called a *compound*.

All living things are made up of different compounds of elements. The starch of a kernel of corn is a compound of carbon, hydrogen and oxygen. Flour is composed of starch and of other compounds containing nitrogen, phosphorus, potassium, and others.

Only a few of the seventy elements are necessary for the growth of plants and animals. The following elements are commonly found in plants and the first ten are absolutely necessary for plant growth: oxygen, hydrogen, carbon, nitrogen, iron, potassium, phosphorus, calcium, sulfur, magnesium, sodium, chlorine and silicon.

Oxygen, hydrogen, and nitrogen are all invisible gases so that we do not see them. Air is mostly a mixture of oxygen and nitrogen so that we know it even if it is invisible. Iron and sulfur occur as elements. Calcium is not ordinarily seen, but quick lime is either calcium or magnesium combined with oxygen. Of course the calcium looks very differently from lime. Silicon and oxygen combined make up the larger part of sand. Salt is a compound of sodium and chlorine.

A green plant is mostly water, often nine-tenths water. Of the other substances, carbon makes up nearly half, nitrogen comes next and there are smaller amounts of the other elements.

No plant can grow if any one of the first ten elements mentioned is lacking, but since the soil furnishes an abundance of iron, sulfur, magnesium, sodium, chlorine and silicon, a farmer does not need to give special attention to these elements. The carbon dioxid of the air furnishes carbon. Water furnishes hydrogen and oxygen. The remaining elements — nitrogen, potassium, phosphorus and calcium — are often insufficient in the soil for the production of a good crop, so that these, particularly the first three, are the elements that farmers buy in fertilizers.

If the school is connected with a high school it will be well to have some nitrogen, hydrogen, and oxygen prepared for the class to study. The high school chemistry tells how to do this.

Words to be spelled and defined.

Element, a substance that cannot be separated into other things.

Compound, a union or two or more elements — a substance that can be separated into two or more things or substances.

Nitrogen, an invisible gas that constitutes about four-fifths of the atmosphere.

Oxygen, an invisible gas that constitutes about one-fifth of the atmosphere.

Carbon dioxid, a compound of oxygen and carbon, sometimes called carbonic acid gas. It is present in small quantity in the atmosphere, and

is the source of carbon in plants; and animals derive their carbon directly or indirectly from plants.

ANSWERS TO QUESTIONS ON THE HORSE.

In the November SUPPLEMENT to the RURAL SCHOOL LEAFLET, we published a list of questions on the horse. Many children have answered these questions, but some have found it difficult to be sure about their answers. We shall, therefore, publish the list with the answers so that you may learn whether your observations were correct.

*Questions.**

1. Where is the horse's knee joint? Which way does the knee bend?
2. Where is its hock joint? Which way does it bend?
3. Can a horse sleep when standing?
4. How are the legs placed when a horse lies down?
5. How does a horse get up — front legs first or hind legs first? How does a cow get up?
6. When a horse starts, after standing, what foot does he put forward first — the left or the right? Fore or back? What foot moves next?
7. When a horse trots, do the two feet on one side move together, or do lefts and rights move together?
8. What does a driver mean when he says that a horse "forges" or "over-reaches?"
9. Name the things that a horse commonly eats. What is a good feed for a day — how much of each thing and when given?

Answers.

M. W. HARPER.

1. The knee joint is situated a little over half way down the front leg between the fore arm, which is above, and the canon which is below. It corresponds to the wrist of a man.

The knee joint bends backward.

2. The hock joint is situated about half way down the hind leg, and is analogous to the knee.

The hock bends forward.

3. A horse can sleep standing, and will do so rather than lie in an uncomfortable place unless there is something the matter with his feet, or he is very tired.

4. When a horse lies down, he draws the four feet together under the body, lowers the head, bends over his knees until they touch the ground, and gently falls over on the side, the right or the left. He may now assume one of two positions, first, if on the right side, he rests on the chest and the abdomen with all four legs half bent and drawn up towards the abdomen, the head and neck swung to the left and probably resting

*These questions were prepared by L. H. Bailey.

on the limbs or against the abdomen; second, he may lie flat on his side with head, neck, body, and legs all stretched out on the ground.

5. To rise, the horse raises the head and neck, extends the forelegs in front of him, raises himself part way up on them; in the meantime he has placed his hind feet on the ground a little removed from the abdomen, and then by a quick effort, brings himself up on his feet.

When a cow rises, she lowers her head and neck, rests her fore quarters on her knees, raises herself up on her hind feet, then by a quick effort rises to her fore feet.

6. A horse in starting to walk after standing, may start off with either his right or his left foot. In case he starts off with his left front foot, almost at the same time he raises his right hind foot. At the walk, a horse moves on diagonal feet.

7. When a horse trots, he moves his right front foot and left hind foot together. At the trot he travels on diagonal feet.

When a horse paces, he moves on his right front foot and right hind foot at the same time. At the pace, he travels on lateral feet.

8. In a horse that forges, the toe of the hind shoe strikes the shoe of the fore foot on the same side.

In a horse that over-reaches, the shoe of the hind foot strikes the front foot in such a way as to cut or inflict a wound.

9. The things that a horse is fed varies according to the locality. In the northern states, Indian corn or oats constitutes the grain part of the meal; while corn-stalks or timothy hay constitutes the coarse part of the fodder. In the south, Indian corn is the common grain, and dry cornstalks the coarse material. On the Pacific Coast, barely is the grain, and wild oats, or the barley and wheat plant, the coarse material. Wheat-bran is also a very good food, and should never be dispensed with in feeding horses, especially the driving horse, which is likely to be not regularly driven. There is nothing better to feed a horse than good sound oats, Indian corn and wheat-bran for the grain part of the meal; nor is there anything better than good sweet timothy, or mixed timothy and clover hay, free from dust, for the coarse part of the ration.

The number of pounds to be fed per day cannot be stated with exactness. That will depend on the kind of food, as well as the size of the horse and the kind of work he is called on to do. We may say that an average sized horse, doing light work, will consume 20 pounds of dry matter, water free; one doing medium work, 24 pounds; and one at heavy work 26 pounds per day of dry matter, of which one-half to two-thirds should be grain, the remainder coarse fodder. The proportion of grain that should be fed, depends on the kind of work the animal is doing. When at hard work, the grain should be increased and the hay diminished; when idle, they hay should be increased and the grain diminished.

The portion of the day's allowance that should be fed at each meal

can be stated with more exactness than the amount. The animal should be fed three times per day, giving one quarter of the day's allowance at least one hour before going to work in the morning. When the morning's task is over, he should be watered, then fed another quarter of his allowance, and watered again on the way to work. When the day's work is done, he hould be watered, then fed the remainder of the food, which will be one-half of his day's allowance. The reason for the large meal at night is because he has now ample time to masticate and digest his food. He should be unharnessed at once, and when the sweat has dried, be given a thorough brushing. A horse cared for in this way will come from the stable full of vim and energy, and ready to attempt any task he may be called on to do.

MEMORY SELECTIONS.

FIG. 34.—"*Ever changing, ever new,*
When will the landscape tire the view?"—*John Dyer.*

"When tillage begins, other arts follow. The farmers, therefore, are the founders of human civilization."—*Daniel Webster.*

"The first farmer was the first man, and all historic nobility rests on possession and use of land."—*Emerson.*

"There's a silence in the harvest field,
And blackness in the mountain glen,
And cloud that will not pass away
From the hill-tops for many a day;
And stillness round the homes of men."—*Mary Howitt.*

What can you learn about the persons from whose writings the above were selected?

CORNELL

Rural School Leaflet

SUPPLEMENT FOR THE CHILDREN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. 1. ITHACA, N. Y., DECEMBER, 1907. No. 4

SUGGESTIONS FOR DECEMBER.

1. A study of the creatures that one finds in the winter time under old logs, loose bark, stones, and the like. This will include dormant insects, cocoons, egg cases of spiders, salamanders, and other forms of life.

2. Studies of the fallen leaves of trees: the different kinds; the structure; the reason for their brown color; the reason for the spots and eaten places. Interesting collections can be made, showing variations.

3. A study of dead trees, and the interesting things that a dead tree may contain; woodpeckers' holes; flying squirrels' nests; red squirrels' nests; wasps' nests; hibernating bats; and other things.

4. Winter birds' nests that will not be used again. Study shape, texture, and materials, using only the more common and easily recognizable kinds.

BIRDS IN WINTER.

"I watch them from the window,
While winds so keenly blow;
How merrily they twitter,
And revel in the snow;
"In brown and ruffled feathers
They dot the white around,
And not one moping comrade
Among the lot I've found."

George Cooper.

FIG. 35.—*Cirro-stratus clouds.*

FIG. 36.—*Nimbus.*

December is a good month to begin bird study. There are not so many to be seen, and in the more open landscape one can find them much more easily. Let us, therefore, start our year's work with three that you may be able to find in winter: the chickadee, the nuthatch, and the brown creeper.

Chickadee.

Description.—About five inches long; black cap with white side pieces; black throat; gray back; under parts, light.

Observations.— 1. It is a short-billed bird with a long tail. 2. It does not creep. 3. The chickadee has two distinct calls, *Chick-a-dee-dee*, and the high, sweet *phoebe* call.

This is the most friendly of the winter birds. If you can imitate the *phoebe* notes, he will answer you, and come near you in the most friendly way. Naturalists have been able to coax the chickadee to come very close to them.

Brown Creeper.

Description.—A little longer than the chickadee; the upper parts brown, white, and rusty; white on the under parts.

Observations.—Note the stiff pointed tail feathers. Watch the brown creeper going up a tree trunk. Notice whether he ever climbs with his head downward. Notice whether he usually begins at the base of the tree or high up the trunk.

The White Breasted Nuthatch.

Description.—About six inches long; black crown; gray back; white face and under parts.

Observations.—Note the short square tail. Does he use his tail in climbing? Note the long slender bill. Watch him as he gets the insect eggs and bugs from the crevices in the bark.

The chickadee, the brown creeper, and the nuthatch are useful farm hands. Why?

HOW CLOUDS ARE FORMED AND WHAT THEY MEAN.

By W. M. Wilson.

Have you even seen a cloud forming? If you live near a lake, or a river, or even a small creek, and will watch on a cold morning in the fall or spring when the water is not frozen over, you may see the fog or vapor rising from the surface of the water.

When a cloud rests on the ground we call it fog, but when high in the air so that we can see only the bottom, we call it a cloud. If you were to go up in a balloon until you were in a cloud, it would look just as it does on a foggy morning. So clouds are simply fog banks floating in the air.

When a cloud forms very high in the air, five or six miles above the earth, the air is so cold that the fog or mist freezes into very fine snowflakes or frost crystals. This makes the high clouds look white, while clouds not so high are darker and more gray in color. If you watch the clouds every day you will frequently see both upper and lower clouds at the same time. You can easily tell them apart because the upper clouds are nearly pure white and show very distinctly against the blue sky. They are usually thin and do not seem to move much. The lower clouds are darker and thicker, making a well-defined shadow when passing before the sun. They seem to move more rapidly than the upper clouds.

FIG. 37.—*Cirrus.*

Clouds are

named from the appearance they present. Some of the kinds of clouds are shown in the illustrations. The upper clouds are called *cirrus* (Fig. 37). They are white, thin, and fibrous or hair-like, which gives them the name of "horse-tails." Sometimes they look like great white feathers or plumes. They are usually seen a day or two before a storm. When the storm comes nearer, the cirrus clouds become thicker, covering the whole sky. They are then called *cirro-stratus* clouds. (Fig. 35). Sometimes they form in rolls or balls, and look very much like bundles of wool. They are then called *cirro-cumulus*. These clouds indicate rain or snow within eighteen to thirty-six hours. It is the cirro-cumulus clouds that the sailors call the "mackerel sky," because the cloud-rolls or balls are said to look very much like a school of mackerel.

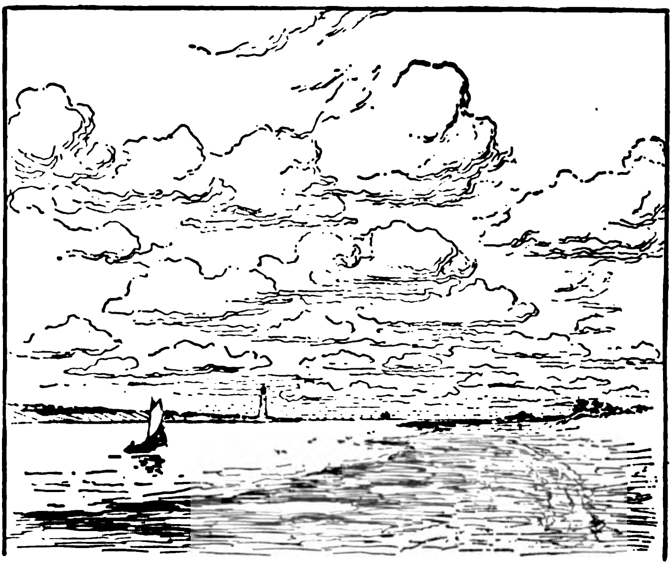

FIG. 38.—*Cumulus*.

The *cumulus* clouds are lower clouds. (Figure 38). They are usually seen in the summer time before a thunder-storm, and are sometimes called "thunder-heads." They are thick, dense clouds with great rounded, castle-like tops and usually straight bases.

Stratus clouds are thick, and of a darkish gray color. Sometimes they are not much higher than the tree tops, and are usually below the tops of mountains. If you were on top of a high mountain, you could look down on the upper side of the stratus clouds. Stratus clouds are the rain-bearing clouds, but as soon as the rain begins to fall from the clouds the name changes to *nimbus*, (Fig. 36) the rain cloud; for the nimbus cloud is a cloud from which rain is falling.

I want you to watch the clouds every day for a week. Ask your teacher to help you to learn to know them by their names. If there are any that you cannot name, write out just how they look to you, and mail your letter to the Cornell Rural School Leaflet.

CORNELL

Rural School Leaflet

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FOREWORD TO THE TEACHER.

By Alice G. McCloskey.

THE Cornell Rural School Leaflets are prepared for teachers, not for pupils. The lessons are not planned for children under twelve years of age. A teacher might be able to use parts of these lessons for young children, but the lessons in the supplement will be found better adapted to the lower grades.

Do not try to take up all the subjects each month. After you have read the Leaflet, decide which lesson is best suited to the conditions under which you are teaching, and which will be of most value in your community. Some teachers may find time to take up all the work, but one lesson carefully given will be of more value than trying to cover the entire ground in a short time.

If these lessons are used merely for supplementary reading, they will not have much value. We plan the lessons so that they will demand actual observational study. If the work is not conducted by means of real things, the educational value is lost. Bear in mind that the lessons are given for the purpose of teaching fundamental principles of agriculture, and if handled properly they will mean an all-round intellectual development for the pupils. This will appear as the work grows and continuing lessons are added.

We wish to caution the teachers to be sure to place name and address on all communications. Sometimes we have no way of knowing where the letters come from. Often the address of the teacher is not given and the postmark has been obliterated.

Lesson XIV.

PROPORTIONS OF A HORSE.

BY M. W. HARPER.

Purpose.—(1.) To demonstrate the correct proportions of a good horse. (2.) To be able to recognize good proportions even when the horse is not placed in a proper position to judge him advantageously.

Materials.—(1.) A horse brought into the schoolyard, if possible. (2.) An instrument for taking measurements which should be made as follows: A piece of soft white pine two inches wide, one-half inch thick, and four feet long; to one end of this, and at right angles to it, tack a similar piece of pine 18 inches long; to the other end strap loosely an ordinary carpenter's square so that it may slide back and forth. Now mark off the long piece in inch lengths, beginning at the inside, as in the cut.

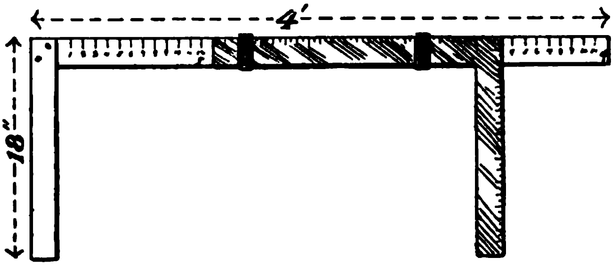

FIG. 39.—*Instrument for measuring horses. Four feet long, eighteen inches wide.*

Note.—At first the teacher may think it is not worth the while to have the boys try to make the instrument for measuring horses. On further consideration, however, it will be seen that this might be made a useful lesson in manual training.

A horse must be in harmony with his surroundings. A light harness horse, which is attractive when hitched to a light run-about, would appear very much out-of-place if hitched to a heavy draft wagon; whereas, the ponderous drafter would seem in place when hitched to such a wagon, and would appear very much out-of-place when hitched to a light run-about. In order to appreciate the beauties of a well-formed and handsome animal, we must place him in the surroundings in keeping with himself. In this connection, the height and length of the horse assumes some importance, as it is not an uncommon sight to see a small horse hitched to a large buggy, or to see a large one hitched to a light buggy. In either case the appearance of the horse is criticized, and yet the animal may be very well-proportioned.

It has been observed that there is a relation between the organs of the horse's body. We have seen that the length of the head was almost equal

to the width and depth of the body, as well as to the length of the shoulder and length of the neck. (Lesson VI.) Now we are to point out the relationship between the *length of the head, the total length of the body* and the *total height of the body*. Take the length of the horse's body by placing the stationary end of the bar, described above, against the point of the elbow, then slide the square along the bar until it reaches the back of the buttock. You will find the distance almost equal to two and one-half times the length of the head.

There are two points from which we measure the height: first, from the highest point of the withers to the ground, and second, from the highest point of the rump to the ground. If we take the height from the highest point of the withers, by placing the stationary end of the bar on the ground and sliding the square up the bar until it just reaches the top of the withers, we shall find this distance almost equal to two and one-half times the length of the head. If we take the height of the horse from the highest point of the rump to the ground, this distance will also be found to be almost two and one-half times the length of the horse's head. Thus we can find three measurements equal to two and one-half times that of the head: (1) the total length of the horse's body from the point of the elbow to the buttock; (2) the height from the withers to the ground; (3) the total height from the rump to the ground.

Lesson XV.

PLANT-FOOD—Continued.
(See Lesson XIII.)

BY G. F. WARREN.

Object.—To see what effect the addition of compounds of nitrogen, phosphorous, and potassium to the soil may have on the growth of wheat plants.

Materials.—Nitrate of soda, muriate of potash, acid phosphate, ten flower pots or tin cans, wheat, soil, the soil preferably from a field that is not very fertile, taken from the schoolyard or an adjoining field if possible, and window space for the pots. Any good-sized boy in a rural school ought to be able to secure soil

FIG. 40.—*A horse having good proportions.*

without much difficulty. About a half bushel will be sufficient, and with a pick-ax this will not be difficult to obtain even in winter. We want this experiment made in the winter, so that there will be plenty of time to think about it before the outdoor work begins in the spring. Wheat is a good kind of plant to work with, since it can stand the cold of the schoolroom. Do not let use feel that this lesson is a failure because sturdy boys have not sufficient energy to get the soil.

Describe each of the fertilizing materials.

Fill each pot with soil and add plant-foods to the different pots as follows:

1. Nothing.
2. Nitrate of soda (one-half teaspoonful).
3. Acid phosphate (one teaspoonful).
4. Muriate of potash (one-fourth teaspoonful).
5. Nitrate of soda and acid phosphate.
6. Nitrate of soda and muriate of potash.
7. Acid phosphate and muriate of potash.
8. Nitrate of soda, acid phosphate and muriate of potash.
9. Same as No. 8, but double the amount of each.

Dig the fertilizer into the soil, then plant about a dozen kernels of wheat in each pot. Label each pot with the fertilizer names. Place the pots in a window where the young plants can grow. When the young seedlings come up, thin them to the same number in each pot. Grow these until the seedlings have several leaves. What is the difference in the color of the leaves in the different pots? Those with nitrogen are usually greenest. Which fertilizers give the greatest increase in growth?

To a limited number of those who cannot readily secure the fertilizing materials, we will send amounts sufficient to carry out this trial, if application is made soon. The freight must be paid by those receiving the materials.

The nitrate of soda which we will send contains 15 per cent. of nitrogen and costs \$57 per ton. The acid phosphate contains 14 per cent. of phosphoric acid (P_2O_5) and costs \$12.50 per ton. The muriate of potash contains 50 per cent. of potash (K_2O) and costs \$42 per ton.

Problem 1.—How much would a pound of nitrogen cost? Phosphoric acid? Potash?

When a farmer speaks of a fertilizer as being a 2:8:10, he means that it contains two per cent. of nitrogen, eight per cent. of phosphoric acid, and ten per cent. of potash.

Problem 2.—Which of the fertilizing materials and how much of each would be needed to give 40 pounds of nitrogen, 160 pounds of phosphoric acid, and 200 pounds of potash? How much would the total weight be? Add enough filler (dirt, to this to make it weigh a ton, and

you have a fertilizer analyzing two per cent. of nitrogen, eight per cent. phosphoric acid, and ten per cent. potash, i. e., a 2:8:10 fertilizer.

Problem 3.—What materials and how much of each would be needed to make a fertilizer that would analyze 3:7:12?

At the College of Agriculture, two tons of manure that had been weighed and analyzed, were left exposed from April 25 to September 22, with the following results:

	April 25 Pounds	Sept. 22 Pounds
Total weight	4,000	1,730
Nitrogen	19.60	7.72
Phosphoric acid	14.80	7.79
Potash	36	8.65

717
No treatment
3520 lbs. hay per acre

716
160 lbs. nitrate soda
320 lbs. acid phosphate
5820 lbs. hay per acre

715
160 lbs. nitrate soda
5590 lbs. hay per acre

FIG. 41.—*Nitrate of soda greatly increases the yield of timothy hay on the College of Agriculture farms. Bulletin* 241.

Problem 4.—What was the value of the nitrogen, phosphoric acid, and potash in the above table on April 25 and on September 22? Use the values found in Problem 1. How much was lost? There are two ways to prevent most of these losses—the manure may be hauled and spread on the land every few days, or it may be kept in a covered shed.

A good fertilizer for timothy hay on the College farms has been found to be one containing 200 pounds of nitrate of soda, 100 pounds of acid phosphate and 50 pounds of muriate of potash per acre.

Problem 5.—How much would this cost per acre?

Problem 6.—What percentage of nitrogen, potash and phosphoric acid would this fertilizer contain?

Problem 7.—About how much hay at the present price in your neighborhood would be worth this much?

In order to be profitable, this fertilizer would have to give enough increase in crop of hay to pay for its cost, interest on the cost, labor of applying and for the extra labor of harvesting the larger crop.

A number of farmers in this state are conducting co-operative tests under the direction of the College of Agriculture in order to determine whether it will pay to fertilize timothy meadows on their farms. Perhaps your school can arrange to have such a trial carried out on a farm adjacent to the school grounds. If such an experiment can be carried out, write for further information about it.

Problem 8.—If some member of the class can bring a copy of the analysis found on the bag of a fertilizer used in the neighborhood, and its cost per ton, the following problem will be most interesting and instructive. How much nitrate of soda, acid phosphate, and muriate of potash would be required to make a fertilizer of this composition? How much would it cost?

Lesson XVI.

PRACTICAL EXERCISE ON FEATHERS.

BY JAMES E. RICE.

Object.—To help the children to discover (1) the utility of feathers to birds; (2) that different parts of the fowl bear different kinds of feathers.

Materials.—A fowl of any kind, brought in a coop. While it is kept at school it should be supplied with food and water. Any of the larger boys will be willing to bring a chicken, turkey, duck or goose for study. If more than one kind of poultry could be secured, the lesson would be more interesting and attractive.

If possible, have the fowl in the schoolroom a few hours before the lesson is given. Encourage the children to find out as many facts as they can for themselves at recess or before the opening of school. The successful naturalist or farmer must acquire a spirit of patient inquiry. Direct the observations of the pupils by a few questions, as: the kind of feathers; the location of the different kinds; any part of the body not covered with feathers. Suggest a little competition by asking which boy or girl can give the greatest number of facts from his observation of the feathers of a fowl.

Method.—The teacher should remove a fowl from the coop head first, holding the legs firmly together to prevent fright and injury. (Fig. 42).

Allow the children to come as near as possible. In a city school I saw a most excellent lesson given on a hen in this way to fifty young children. The lesson lasted a half hour. The hen did not seem disturbed, and the pupils were intensely interested.

Suggestions for study.

1. The pupils can learn that the feathers are non-conducting, by observing the difference in the heat of the body when the hands are placed on the feathers, and when they are placed between the feathers against the skin. Discuss the fact that the warm coat of feathers is one reason why fowls suffer from the heat in the excessively warm weather, and why they are able to endure so much cold in the winter. What can a fowl do when she wants to be cooler? What can she do when she wants to be warmer?

2. Ask the children whether they ever saw a turkey sleeping on the roost in a cold night. Did she have her head under her wing? Bring out the fact that the breath warmed the body and the feathers protected the head.

3. Before the pupils leave the schoolroom some cold night, ask them to notice when they go home whether the fowls keep close to the roost. Ask them whether they have ever seen a duck, a goose, a turkey, or other fowl standing in the snow or on the ice, and whether they stand on one foot or both feet.

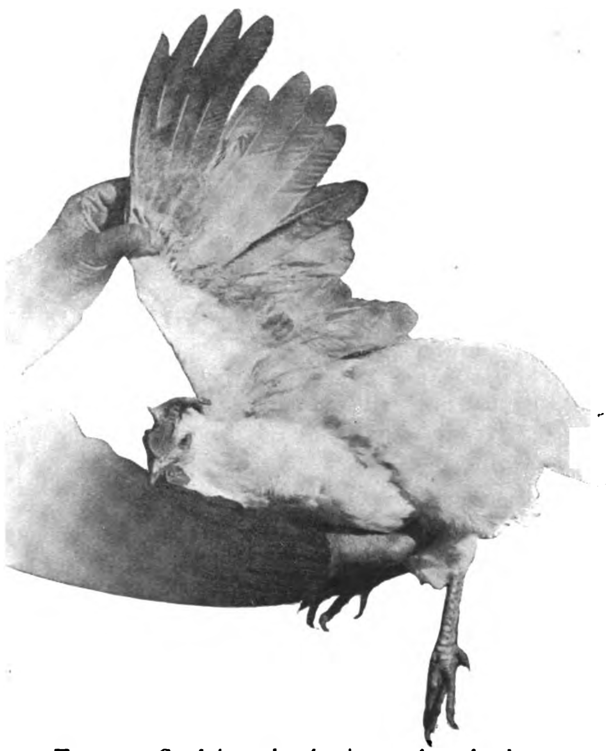

FIG. 42.—*Studying the feathers of a fowl.*

4. Spread the wings and tail (Fig. 42), so that the different feather sections may be seen. Note that in the wing and tail one feather overlaps another so that each feather braces the other during flight. Discuss the use of the turkey's wing for a fan or duster. Are the feathers lapped over one another? Why are the feathers thus arranged? Do several boys skating arm in arm find it harder skating than they would if they skated separately? What comparison is there between the boys skating

against the wind and the arrangement of the feathers of the wing when a bird is flying?

5. Observe that the lighter wing feathers (secondaries) are tucked up under the heavier feathers (primaries).

6. Fold and unfold the wings and observe how one feather overlaps another, forming a thick shield. What utility can you suggest for this? Why does the baseball catcher have a breast-pad? Consider whether the folded wing protects the fowl's body in a similar way to that in which the pad protects the ball player.

7. Spread the tail, then fold it, and swing it from side to side to observe its use in steadying the fowl in flight? Of what does it remind you? Did you ever steer a boat? What is the similarity between the rudder of a boat and the tail of a bird in flight?

8. Notice how the back feathers also overlap one another. Can you suggest why the feathers are thus arranged? What comparison can you make between the arrangement of the back feathers and shingles on a roof?

Lesson XVII.

LESSONS IN DAIRYING.

In most dairy sections the teachers have shown much interest in the lessons on milk, and the work has been taken up with enthusiasm. We want to make the lessons valuable, and will be glad of any suggestions from the teachers.

In the October Leaflet we offered to send apparatus for making the Babcock test to the first ten teachers in rural schools making application in ten different counties. The apparatus has been sent to the following teachers:

1. Mrs. Elva H. Caswell, Cortland, Cortland County.
2. Miss Minnie B. Collins, Mechanicsville, Saratoga County.
3. Mr. Albert J. Farrell, Watertown, Jefferson County.
4. Miss Laura B. Gelser, Castorland, Lewis County.
5. Miss F. E. Martin, Westfield, Chautauqua County.
6. Miss Susan Moore, Seneca, Ontario County.
7. Miss Florence N. Brown, Lockport, Niagara County.
8. Mrs. Gertrude Van Aken, Port Ewen, Ulster County.
9. Miss Ethel L. Fisher, Clarence, Erie County.
10. Miss Jean Wilklow, Cuba, Allegany County.

We now have on our waiting list the following names:

1. Miss Alice E. Derby, Cassadaga, Chautauqua County.
2. Miss Birdie Crosby, Brocton, Chautauqua County.

3. Mr. Orville Eichenberg, Monroe, Orange County.
4. Mr. Eugene L. Moe, Burke, Franklin County.
5. Miss Matilda U. Bower, Catskill, Greene County.
6. Miss Katherine A. Donovan, Chateaugay, Franklin County.
7. Mr. Frank O. Dodge, Norway, Herkimer County.
8. Miss Elizabeth J. Fletcher, Andes, Delaware County.
9. Miss Florence E. Chase, Hilton, Monroe County.
10. Miss Cora G. Kenney, Nunda, Livingston County.
11. Louis A. Blodgett, Water Mill, Suffolk County.
12. Miss Wills, Glenwood, Tompkins County.

FIG. 43.—*First lesson in dairying*

13. Miss Mary E. McCarthy, Malone, Franklin County.
14. Burr H. Tupper, West Danby, Tompkins County.
15. Miss Georgia Gorton, Bolivar, Allegany County.

From the above, it will be seen that twenty-five applications for the Babcock Test apparatus have been made to date. We shall be able to supply thirty schools before the close of the year. There is still opportunity for teachers who are interested to make application.

The article this month is given so that pupils may be taught why a study of milk and milk products is important—to arouse their interest in the value of the subject; observations and experiments will follow.

SOME NEW YORK DAIRY STATISTICS.

BY R. A. PEARSON.

Few people realize how great is the dairy industry of New York State. The last census tells us that in 1899 there were 1,501,608 cows on New York farms. If these were arranged like a column of soldiers standing ten abreast in a line and the lines close together, the column would reach from Buffalo to Albany. The value in one year of the milk produced by these cows or the products made from their milk is, in round numbers, $55,000,000—more than the value of the same products for any other state, and equal to about three fourths of the total value of the gold mined in the United States in one year.

Using round numbers we may say that 6,000,000,000 pounds of milk is produced annually by New York cows (2.15 pounds is the weight of one quart). Milk is used for: (1) Food, (2) Butter, (3) Cheese, (4) Condensed Milk, (5) Miscellaneous purposes.

Milk as food.— It is estimated that the average person uses .6 of a pint of milk daily as a beverage or in food. This is about one glassful and the amount might well be increased as milk is most nutritious and cheap as compared with other foods. On this basis, the more than seven million residents of our state use as food every year over 1,600,000,000 pounds of milk. Most of this has to be carried a considerable distance to the consumer. A part of the milk used in New York City is hauled in trains from stations three to four hundred miles away. According to our State Department of Agriculture, there are about 700 milk stations in the State. As a rule the milk when delivered in our largest cities is twenty-four to thirty-six hours old. This is one reason why milk for the market must be handled with special care. A small quantity of milk is used also for making cream for food.

Butter.—About twenty pounds of milk is necessary for making one pound of butter. Thus about 2,300,000,000 pounds of milk is used in the manufacture of about 115,000,000 pounds of butter—the annual output of the State. Nearly two-thirds of this butter is made on farms and the balance is made in factories of which there are nearly 600.

Cheese.— About ten pounds of whole milk is used in the manufacture of one pound of "full cream" or "cheddar" cheese. Practically 100,000,000 pounds of this cheese is made annually in New York, and almost all of it is made in cheese factories. Thus full cream cheese accounts for 1,000,000,000 pounds of milk.

About 30,000,000 pounds of other kinds of cheese is made. These include "skim" cheese which is made from partially skimmed milk, and at least a dozen other varieties, some of which are imitations of foreign cheese. It is not possible to state how much milk is used for these miscellaneous kinds of cheese.

There are about 900 factories in which cheese is made, and about 200 others in which both cheese and butter are made.

Condensed milk.—Three and one-half to four quarts of milk is required to make one quart of condensed milk. It is reported that about 20,000,000 quarts of condensed milk is made, and most of it in about twenty-five condensaries. This would use about 150,000,000 pounds of milk.

Miscellaneous uses.—These include the use of milk for feeding calves, and a small quantity which is dried for baking and other food purposes. Our State Department of Agriculture reports that about 10,000,000 pounds of casein is made annually from skimmed milk, therefore this is an important by-product mainly in butter factories.

In these days of keen competition, the most profitable use of milk in any district is a matter requiring careful study. Points which the dairyman must consider include the following:

(1.) Cash value of milk to be used as market milk, for butter or cheese making or for other purposes. This means some knowledge of the leading dairy markets, and definite knowledge of the fat-test of his

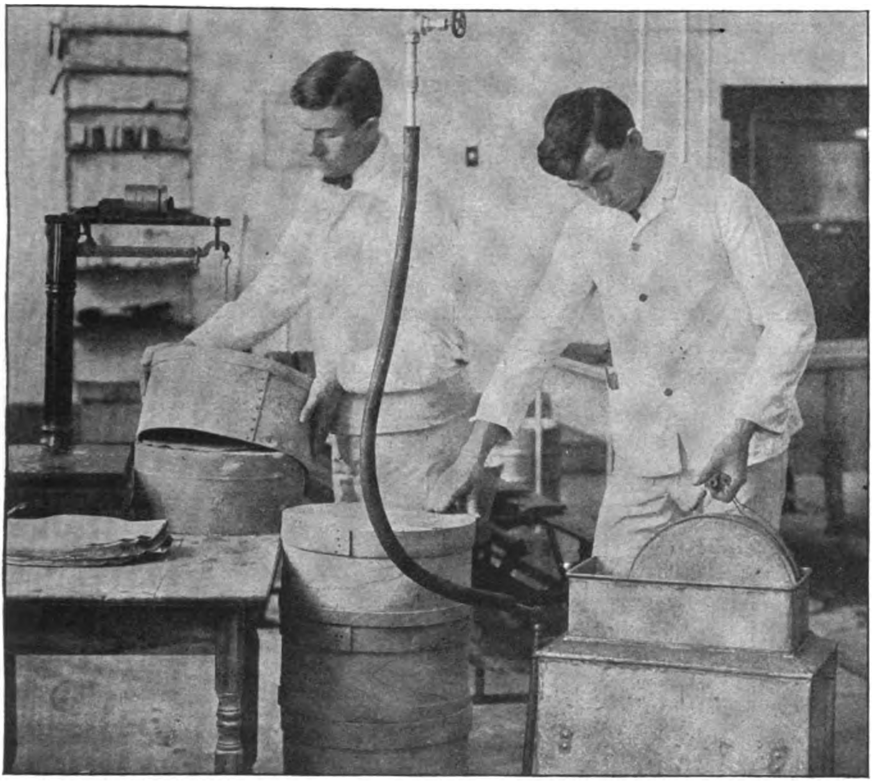

FIG. 44.—*Making cheese at the College of Agriculture.*

milk, and what differences are required by the different purchasers in manner of producing and handling.

(2.) Cost of manufacturing products from milk, whether at home or in a factory.

(3.) Cash value of the by-products—skimmed milk and whey.

(4.) Cost of delivery of milk to be used for different purposes.

(5.) Permanency of market.

(6.) Responsibility of parties who offer to buy milk.

MEMORY SELECTIONS.

"Whatever your occupation may be, and however crowded your hours with affairs, do not fail to secure at least a few minutes every day for refreshment of your inner life with a bit of poetry."—*Eliot Norton.*

"Love the things nearest at hand; and love intensely. If I were to write a motto over the gate of a garden, I should choose the remark which Socrates made as he saw the luxuries in the market: 'How much there is in the world that I do not want!'"—*L. H. Bailey.*

FIG. 45.—*We minded that the sharpest ear*
The buried brooklet could not hear
The music of whose liquid lip
Had been to us companionship,
And in our lonely life had grown
To have an almost human tone.
—From Snowbound, J. G. Whittier.

CORNELL

Rural School Leaflet

SUPPLEMENT FOR THE CHILDREN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. I. ITHACA, N. Y., JANUARY, 1908. No. 5

WINTER BIRDS.

OF THE winter birds the chickadee, the nuthatch and the brown creeper were discussed in the lesson last month. This does not mean that you are to give up the study of these three birds, for we can learn something new about them now. Place the description of the nuthatch, the chickadee, and the brown creeper on the blackboard, and add three more for January. We shall choose three woodpeckers: the downy woodpecker; the hairy woodpecker; the red-headed woodpecker.

The Downy Woodpecker.

Description.—Length 6¾ inches; upper parts, black and white, scarlet on the nape of male bird; upper tail feathers barred with black.

Observations.—Try to find the many different ways in which the downy woodpecked is a friend to the farmer. He has been called "a little orchard inspector." He is an industrious digger of grubs and caterpillars. Look for him in orchards, woods, and among shade trees.

The Hairy Woodpecker.

Description.—About three times as long as downy; similar in coloring; upper tail feathers white.

Observations.—The hairy woodpecker is not so social as Downy but keeps more closely to the woods. If you chance to seen one, note what he does. He will look very much like an over-grown Downy. Try to find out whether he is a useful farm hand.

The Red-Headed Woodpecker.

Description.—About the size of a robin; head and neck, red; back and tail, black; under parts, white; upper tail coverts and greater part of secondaries, white.

Observations.—If food is plentiful, the red-headed woodpecker remains over winter. If you see a bird on a telegraph pole, or a fence post, find out whether it is a red-headed woodpecker. Do you find beech

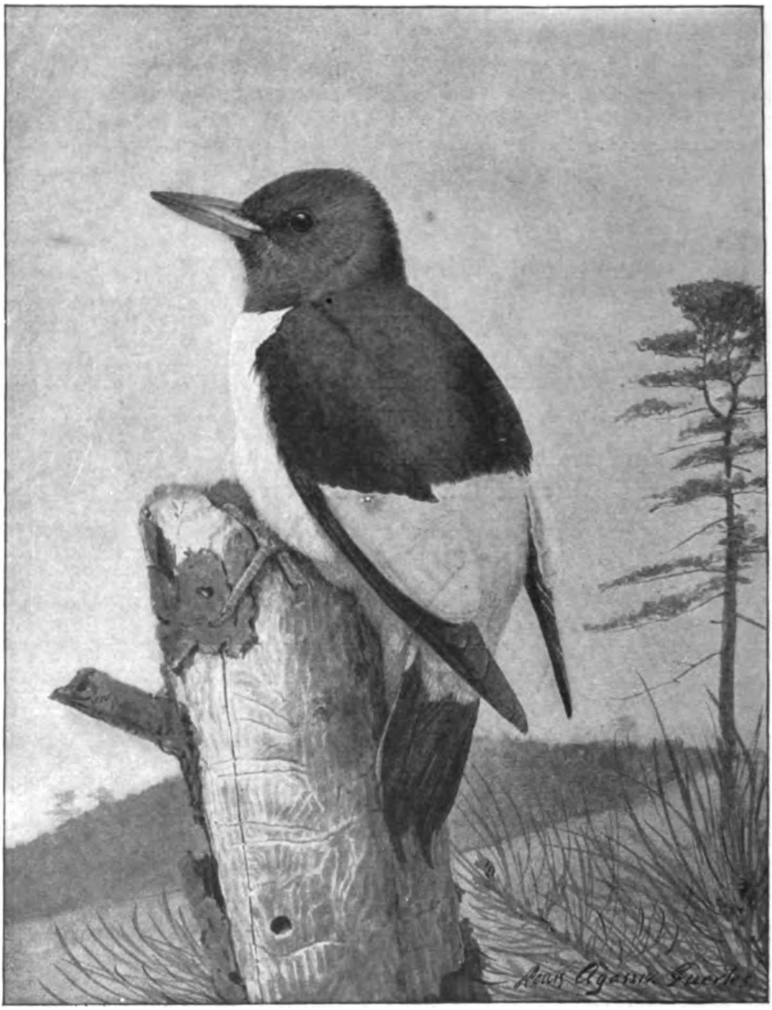

FIG. 46.—*The red-headed woodpecker.*

nuts or other food stored in decayed trees, under a bit of raised bark, in cracks in the bark, or in gate posts? If so, a red-head may be about.

LESSONS ON THE WEATHER.

A NUMBER of boys and girls have been interested in the lessons on the weather. This is always a good subject for nature-study, and we hope to have several lessons on weather during the school year. This month we will learn something about rain, and next month about snow. Very often it rains in winter and when you know something about the rain, it will help you to understand the snow storm better.

A lesson on rain should be given some day when it is raining, if possible. Then I hope your teacher will let you go to the windows to listen to the music it makes, and to watch the drops fall. Boys and girls should learn to like the rain, and should enjoy watching it as it comes down over the fields. I like to watch it fall on the roofs, on the bare branches, on the snow. I like to watch it fall on the backs of the little sparrows and the red-squirrels. They do not seem to mind it.

Coming at this time of the year, rain usually promises a future crust on which young folks can slide. There is always some cheerful promise in the shining drops. Many persons are sad on rainy days, but there are some whom the rain makes happy. I think it would make us all happy if we could learn to look at it in the right way.

In the following lesson, an experiment that can be made by boys and girls is given. It is a good thing to have experiments in the schoolroom. A tea-kettle that can be placed over an alcohol lamp or on the stove will be needed. Some boy or girl will be able to bring this for an afternoon.

HOW WATER GETS INTO THE AIR.

BY WILFORD M. WILSON.

"The soft gray rain comes slowly down,
Settling the mists on marshes brown,
Narrowing the world on wood and hill,
Drifting the fog down vale and rill."—*L. H. Bailey.*

You have often seen the rain falling. Did you ever try to think how the water that falls as rain gets into the air? Here is an experiment that you can make at home or at school: Put about half a pint of water into a tea-kettle, and place it over a good fire. Take a dinner plate or a piece of glass, and leave it out of doors where it will get cold. Now go back to the tea-kettle, and very soon you will see a little cloud of vapor coming out of the spout. If you watch this cloud closely, you will see that it disappears when it gets a little distance from the spout.

If the fire is hot, you will find in a short time that there is no more water in the tea-kettle, and you say it has "boiled dry." Now, what

has become of the water you put into the kettle? Did it come out of the spout as steam or vapor? If so, where is it? Let us see. Put a little more water into the kettle, and get your plate or glass that you put outside to get cold. When the vapor begins again to come out of the spout, hold the glass in the cloud a little distance from the spout. Very soon you will see that the glass is wet, and in a short time water will run down the side next to the kettle and drop off. What does this show? If the weather is cold out of doors, you may see the window panes become cloudy, and if you have boiled away a pint or more of water, you may see the little streams of water running down the window panes.

You cannot see any steam or vapor near the windows nor in the air of the room except near the spout of the tea-kettle, but you may be sure that all the water you put into the kettle is now in the air of the room. You have taken some of the water out of the air with your cold plate, and some has been taken out by the cold window panes. If you could find some way to cool the air of the room suddenly and catch the water as it comes from the air, you would get back every drop of the water you put into the kettle. What change did the heat from the fire make in the water? What change did the cold glass or the cold window pane make in the vapor in the air?

It is not necessary to boil the water to make the change take place. Boiling only makes it change faster. When your mother hangs the clothes out on the line even on a cold day, they soon become dry. The heat from the sun is quite enough to cause the water in the clothes to change to vapor and pass into the air. This change is going on all the time from the surface of the ocean, the lakes, the rivers, and the moist earth, and although you cannot see it, the air always contains more or less water in the form of vapor.

MEMORY SELECTIONS.

"Hear the woodpecker, rap-a-tap!
See him in his cardinal's cap!"—*Maurice Thompson.*

"The busy nuthatch climbs his tree,
Around the great bole spirally,
Peeping into wrinkles gray,
Under ruffled lichens gay,
Lazily piping one sharp note
From his silver mailed throat."—*Maurice Thompson.*

"The squirrel came running down a slanting bough, and as he stopped twirling a nut, called out rather impudently, 'Look here! just get a snug-fitting fur coat and a pair of fur gloves like mine and you may laugh at a northeast storm.' "—*Thoreau.*

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Vol. I. ITHACA, N. Y., FEBRUARY, 1908. No. 6

FOREWORD.

THE Cornell Rural School Leaflets are prepared for the purpose of helping teachers who desire to give instruction in agriculture, and who feel that they have not sufficient preparation for the work. We are not following as complete and consecutive work as would be given in a textbook on agriculture, but endeavoring to give suggestive lessons that will open the way for more definite instruction in agriculture later. The lessons given in the Leaflets are prepared by persons who are teaching the subjects in the College of Agriculture.

It is difficult to give lessons in agriculture without some equipment for laboratory work. We try, however, to have the work so planned that every teacher, even in the poorest rural school, will be able to give some instruction from each lesson that will be fundamental to agricultural knowedge. Every teacher may not be able to give the entire lesson as we suggest in the Leaflet. Many will be able to do this, and others should give as much as their opportunities will permit.

Make the lesson as live as possible. Whether it be on the snow storm, on the horse, on plant-foods, or on milk products, have actual material with which to work. It will not require a great deal of effort to provide material for these lessons, and teachers will be fully repaid by the increased interest.

One teacher recently wrote, "Do not give us too much farm in the Leaflets, we like nature-study." Such a request is encouraging, because we are hopeful when we find teachers willing to put their pupils in touch with the out-of-doors. This is always fundamental to agriculture. All agriculture is nature-study, but, since most educators have recognized the value of general out-of-door study, the College of Agriculture is now able to center its interest more and more on that part of nature-study which is closely allied to practical agriculture. Many excellent books

have been published recently along the lines of general nature-study, but as yet literature is limited in elementary agriculture. We are, endeavoring, therefore in the CORNELL RURAL SCHOOL LEAFLET to help teachers who wish to make a beginning along the line of definite instruction in agriculture for farm boys and girls.

Every teacher in a rural school should help his pupils to become familiar with the out-of-doors. If there are boys and girls in his class between the ages of twelve and sixteen, they could be inspired with very little effort to become interested in the trees, the wayside plants, and the animal life about their school and home. At the College we shall be willing to identify plants and animals from accurate descriptions or good specimens.

Encourage the children to write to the College of Agriculture, either to Uncle John, or to the professors who write the articles for the Leaflet. Every farm boy and girl in New York State should know something of his College of Agriculture, and learn how to secure information relating to farm life from teachers competent to give it. If the pupils acquire the habit of consulting expert judgment while they are young, they will know how to do it in later life when they have real farm problems to meet. The teacher who gives this opportunity to her pupils may be establishing a relation between a boy and a higher institution of learning that may have a far-reaching influence on his future life.

Lesson XVIII.

TYPES OF HORSES.

BY M. W. HARPER.

Object.—To teach the pupil to see a horse when he looks at him.

By comparing the horses we see on the street, we will observe that they are of different forms or types. Some possess a form that enables them to draw very heavy loads, but at a slow pace. Some are so formed as to draw light loads and at a very rapid pace. Between these two extremes we will observe a form that is intended to draw a very moderate load, but with high action and much style. These are three distinct types and they are called ***draft horses, driving horses, and coach horses.***

You will observe that the draft horse has short legs, a heavy body, a short, thick neck, broad, deep chest and shoulders, strong hocks, and rather large joints and feet. With the draft type, weight is one of the most important considerations, for a true draft horse must be heavy as compared with the coach or driving horse. A draft horse in fair condition may weigh anywhere from 1,500 to 2,000 or more pounds. The greater the weight, as a rule, the more efficient the draft horse will be. If you will watch the draft horse as he draws a heavy load, it will become very

evident that the heavy horse in harness brings greater power into the collar than does the light one.

There are several different breeds of draft horses. The Percherons, Belgians, Clydesdales, and English Shires are probably the most familiar. The Percherons came from France, and at first they were gray. Now the blacks are in the most favor. The Belgians, usually bay, came from Belgium. The Shires, commonly bay, brown, or sorrel, came from England. The Clydesdales, quite similar in appearance to the Shires, but often smaller and more active, came from Scotland.

FIG. 47.—*A carriage horse.*

The driving horse has a longer and more graceful neck, a narrower chest, a longer body, and longer legs than the draft horse. In the driving type, weight is not so important as in the draft type. Speed and endurance seem to be the principal points sought in the roadster or driver, and less uniformity is found in this type than in the draft or coach type. The driving horse varies widely in height, weight and conformation. In conformation this type tends to be angular, the muscles and joints showing prominence, with the ribs more or less noticeable. There is relatively less body and more legs, a thinner neck with muscularity at the croup and quarters. The American trotter or pacer is the common type used for this work. These horses are bay, black, brown, roan, and in fact likely to be almost any color.

The coach horse or carriage horse as it is frequently called, is intended for the special purpose of drawing coaches and other fashionable vehicles. such as are commonly seen on the streets of every city. In general appearance the coach type shows smooth graceful lines, with a general fullness in all parts. The neck is of moderate length and gracefully arched, the shoulders long and sloping well into the back, the body round, short on top and long below, and the legs of good length, showing cleanness, good bone, and plenty of muscle. In this type of horse, style and action are the most important factors. The coach type of horse should possess rather high, bold knee action of a flashy sort. The hocks should be slightly bent or flexed, and the legs carried well up to the body when in action.

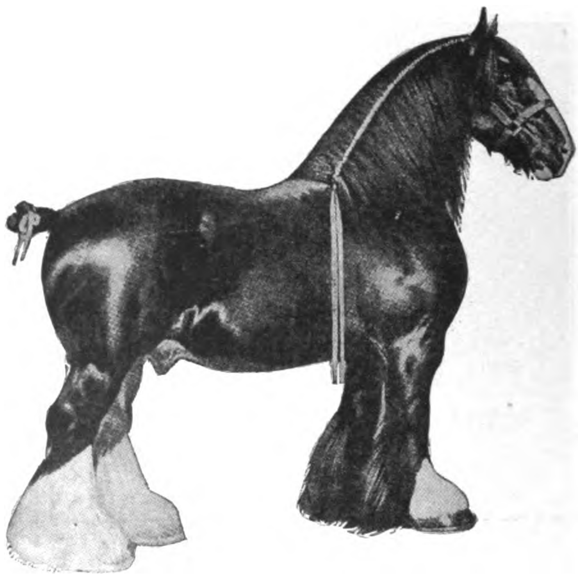

FIG. 48.—*A draft horse.*

There are several breeds of coach horses,—the hackneys, the French coach and the German coach being the best known. Of these, the hackney is perhaps the most desirable as a coach horse because of his high action and pleasing style. The hackney came from England, where for centuries he has been greatly patronized as a saddler and a roadster. In color the hackney varies, but chestnuts are at present in the greatest demand. The French coach came from France. In color they vary quite a little, bays and browns being the most common. The German coach came from Germany where he has been bred for centuries. In color they are usually bays, blacks, or browns.

One must not get the idea that all the horses he observes on the street will fall into one of these three types, for the horses that you usually

see are mere common horses of no particular type, and are used for a great variety of purposes. These common horses have not been bred true to any type, but are oftentimes the result of crossing the various types mentioned, or are descendants of common horses. They are not so efficient for any given purpose, and are not so valuable as though bred true to a given type.

Lesson XIX

LEGUMES AS FOOD

BY G. F. WARREN

Object.—To study the value of legumes as food.

In former lessons we have learned that nitrogen is one of the very important plant-foods, and that leguminous plants are able to secure a

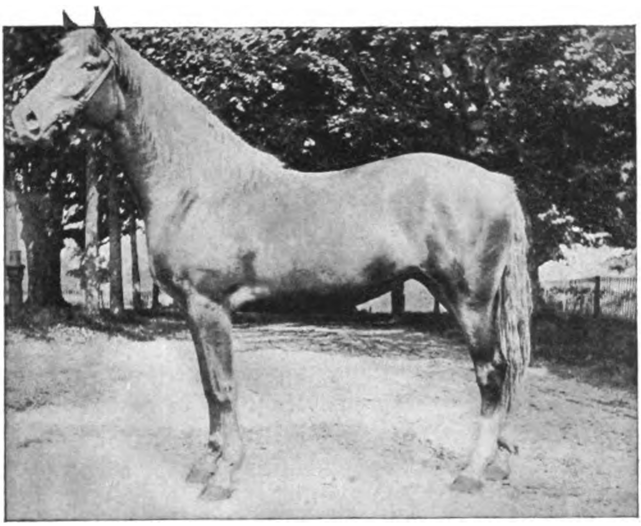

FIG. 49.—*A driving horse.*

part of their nitrogen from the air, provided the proper bacteria are present for the formation of the nodules on the roots.

All plants can take nitrogen from the compounds in the soil. Legumes are no exception. They have two ways of obtaining nitrogen; hence, we will not be surprised to learn that they contain a higher percentage of it than do other plants. A very common error is to suppose that because legumes can obtain some nitrogen from the air, they do not need much of it in the soil or fertilizer. Nearly all legumes require a rich soil for their successful growth. They have two ways of getting nitrogen, and can live by either way alone, but need both ways in order to produce good crops.

The following table shows the percentage of nitrogen and protein in a few crops. The first two are legumes.

TABLE I

	Nitrogen	Protein
Alfalfa hay	2.29%	14.3%
Clover hay	1.96	12.3
Corn fodder with ears	0.72	4.5
Timothy hay	0.94	5.9

Nitrogen does not occur in plants as an element but as a compound. The compounds that contain nitrogen are commonly called protein, nitrogenous compounds would be a more accurate name. There are a number of these compounds. On the average they contain about 16 per cent. of nitrogen. When a chemist determines the per cent. of protein he finds the amount of nitrogen and multiplies this by 6¼ to get the per cent. of protein. One of the very important constituents of our food is protein. The following table gives the amount of water and protein in a few foods:

TABLE II

	Water	Protein
Green peas	81.8%	3.4%
Dried peas	9.5	24.6
Dried beans	12.6	22.5
Peanuts	9.2	25.8
Wheat flour	12.1	11.2
Lean beef	70.0	21.3
Milk	87.0	3.3
Eggs	73.7	14.8
Potatoes	78.3	2.2

It will be seen that these legumes contain over twice as much protein as wheat flour. Peas and beans may be used to replace the protein of meat to a considerable extent. They are a little harder to digest, so are not ordinarily used in very large quantities except by people who have outdoor work.

The most important way in which legumes furnish protein for human food is indirectly. Of course, an animal that produces lean meat, eggs, milk, or other product that is high in protein must have much protein in its food. Alfalfa and clover hay are the indirect source of much of the protein in our milk and meat.

Problem 1. What percentage of nitrogen is there in each of the foods in Table II?

Problem 2. Another way to compare these is on the basis of dry matter. Green peas contain 81.8 per cent. of water and 3.4 per cent. of protein, or 18.2 per cent. of dry matter of which 18.7 per cent. is protein.

How much dry matter is there in each of the other foods? What percentage of the dry matter is protein?

Protein is only one of several important parts of food. For a discussion of the other parts see:

Cornell Experiment Station Bulletin 154—Computing rations for farm animals.

Farmers' Reading-Course Bulletins Nos. 6, 7, 8—Balanced Rations for stock.

Farmers' Bulletin 121. Legumes as food.

The first two may be obtained by writing to the College of Agriculture. For the last one, write to the Secretary of Agriculture, Washington, D. C.

Lesson XX

THE PARTS OF A FEATHER

By J. E. Rice

Object.—To teach the structures of feathers. A knowledge of the kinds of feathers and the markings of them is essential to learning the different breeds of poultry. Therefore, this is an important lesson, and if given at all, it should be given with some spirit. The teacher should have feathers that have been taken from different parts of a fowl or fowls, in order to show how the feathers differ in size, shape, and structure. These samples may be collected most easily from a fowl that has just been killed, and should be mounted and kept for future lessons.

Materials.—(1) A fowl or fowls of the same breed or of different breeds.

(2) Suitable coops with food and water.

(3) Drawing paper, pencils, and erasers.

(4) Blackboard and color crayons.

(5) Microscope or magnifying glass, if possible.

Method.—Have the pupils study the live fowl, noting the structure of the feathers on different parts of the body. This might be done at times when other lessons are completed.

(a) Slit the quill of an old feather, and examine the pith.

(b) Place the different parts of a feather under a magnifying glass and let each pupil examine them, stating what he sees.

(c) Make a drawing of any feather from any part of the fowl, and name its parts: fluff, tip, quill or shaft, barb, web. (Fig. 50.)

DEFINITIONS.—*Quill or Shaft.* The rib-like portion which supports the web, and gives strength to the feather.

Web. The thin, flat, fan-like part of a feather formed by the uniting of the barbs.

Barb. The separate sections of a feather, which, when united, form the web and when separate, form the fluff.

Fluff. The portion of the feather where the barbs are separate. Usually next to the body and covered by the webs of other feathers.

Hunt for feathers which branch from the quill like branches on a tree. Examine fowls during different seasons of the year to find out whether

the branching occurs more frequently during the warm or the cold seasons. Notice how the softer, downy feathers grow on the most protected parts of the body, and that the harder feathers are found where the body is most exposed and liable to injury.

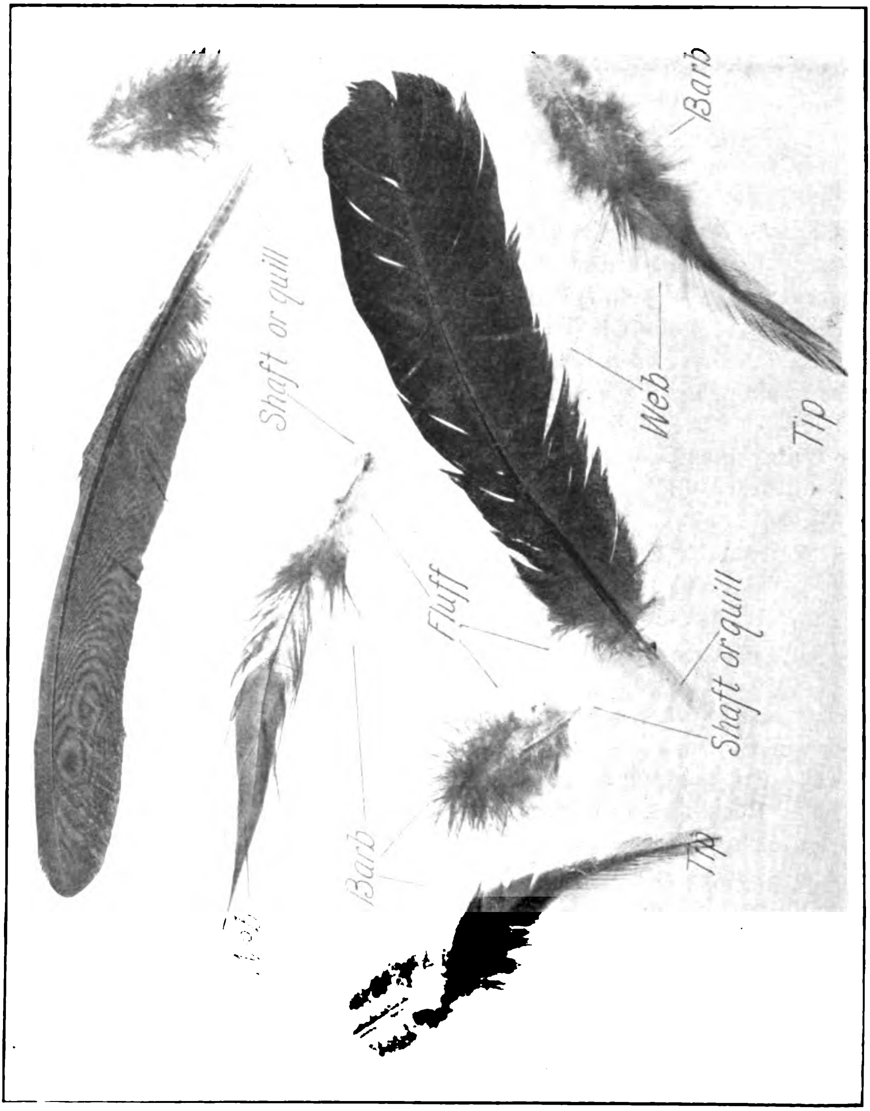

FIG. 50.—*The parts of feathers.*

It would be well to make as complete a collection of feathers as possible for use in the classroom. Every time a feather is brought into the school, it should be mounted, and the children should decide from

what part of the fowl the feather was taken. Any teacher will see that this will at once interest the children in finding feathers, and in noting poultry more closely as they see them in the barnyard. Patient inquiry is ever fundamental to scientific work.

THE LESSONS ON POULTRY

Professor Rice has been preparing a series of lessons on poultry for the CORNELL RURAL SCHOOL LEAFLET. His expert knowledge on the subject will be of benefit to every child in the rural districts in New York State. The lessons are planned so that children may have an educational outlook to the subject.

One who is successful in raising poultry must know poultry, not merely a few facts on the practical side of poultry raising. There are problems that come to the farmer in this line of work that he must solve for himself. He can do this best if he has some scientific basis for the work.

One or two teachers have asked us to tell the children how to make money in poultry raising, rather than to give them instruction along scientific lines. This is a mistaken idea. If the observation of a child is trained so that he can readily see, and his reasoning powers are sufficiently developed to find out something about what he sees, he will be prepared to carry out practical problems.

In his articles this year Professor Rice is endeavoring to give children a knowledge of poultry. If teachers will see that these lessons are properly given with actual material, the children will have a fundamental preparation for poultry raising. Let knowledge come first, and practical suggestions can then be given with some hope of results.

Lesson XXI

WHY MILK SOURS

By W. A. STOCKING, JR.

Object.—To call the pupil's attention to some of the invisible forces constantly working about us, and to explain the cause of one of the things with which we are all familiar—why milk sours.

Material.—A little milk, a few glass jars and a thermometer.

Everyone knows that if milk is allowed to stand in a warm room for any length of time, it becomes sour and finally curdles. Not everyone, however, knows *why* these changes take place in the milk.

Milk becomes sour and curdles because it contains bacteria, which change the milk sugar into lactic acid. At first, milk usually contains

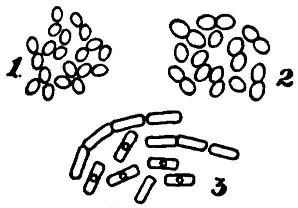

FIG. 51.—*The form of some of the bacteria common in milk.*

only a small number of these acid-producing bacteria, but they multiply very rapidly, and when they have produced enough acid, the milk begins to taste sour, and as the bacteria grow and the amount of acid produced increases, the milk becomes more and more sour until it finally curdles.

These organisms which cause the milk to become sour belong to a group of minute plants. They are the smallest plants that we know anything about; so small, in fact, that it takes many thousands of them placed side by side to make a row an inch long. They are so small that we cannot see them with the unaided eye, and if we want to look at the individual bacteria plants, we must look at them through a high power microscope. It is because of their extreme smallness that we cannot see them in the milk. All we can see are the changes which they produce in the appearance of the milk and in its taste. Note Fig. 51. Three forms of bacteria are given: 1 causes milk to sour and is the organism used for ripening cream; 2 produces gas and is the cause of gassy cheese; 3 causes the milk to putrify.

Besides being the smallest in size, bacteria are also the simplest in form of any of the plants. A mature, full-grown bacteria plant consists simply of a little cell or sack filled with protoplasm. Some of these plants are round like a ball, while others are cylindrical in form, as shown in the illustration. But no matter which shape the organisms are, the structure is always very simple.

Not all bacteria are capable of producing acid as a result of their growth, and in a later lesson we will discuss some of the other things which bacteria do. But in this lesson we will consider only the organisms which can produce acid in milk.

The growth of the acid-forming bacteria in milk can be observed in the following way:

Secure a quantity of milk, mix it thoroughly, and pour equal quantities into each of four pint bottles or glass fruit jars. (These jars should be thoroughly washed and scalded before the milk is poured into them.) Cover the jars or bottles with paper to prevent the entrance of dust. Then place one bottle in a dish of ice-water, one in water at 55° or 60°, one at 70° to 75°, and the other at 90° to 100° Fahrenheit. It will be well to shake the bottles frequently when first put into the water, until the milk becomes the same temperature as the water.

Now keep the water in the dishes at the above temperatures, and notice when the milk in each jar first tastes sour, and also when it curdles.

Like the higher plants, bacteria grow best at warm temperatures, and

much more slowly if kept cold. For this reason the bacteria in the warm milk will grow faster and change the milk sugar into acid more rapidly, causing the milk to sour and curdle before it does in the jars which have been kept at the cooler temperatures.

NOTE.— It will be well to start this experiment as early in the morning as convenient, and maintain the different temperatures during the day, making an occasional observation to determine when the milk begins to sour.

It will be well to start with milk which is a few hours old, so that which was kept at the warmest temperatures will curdle before night. Probably the bottle kept in ice-water, and possibly the one at 50° will not curdle before the next day.

It can be explained to the pupils that the souring and curdling of the milk is the direct result of the growth of the bacteria, which are too small to be seen.

FIG. 52.—*Method of keeping samples at different temperatures.*

THE BABCOCK TEST

Many encouraging letters have been received from teachers who have made experiments with the apparatus sent out for the Babcock test. We find that the teachers are making the most of this opportunity for giving some definite instruction in agriculture. Following is a letter received from one of the teachers who feels that the work has been worth the while.

R. F. D. 2, CASTORLAND, N. Y.,
Dec. 18, 1907.

Dear Miss McCloskey:

We have used the tester in our school, and with very good success.

The first day I explained the different utensils used; another, the scale on the bottles and gave exercises in reading different tests; the next, the children practiced reading with oil and water in the bottle; another, the use of pipette and acid measure. When they had become proficient in using the tester with water, we made a real test, following directions accurately. One sample tested six per cent.; another three and two-

tenths, and another four and eight-tenths. We made two tests of one sample and both were the same.

The children did all the work, and the readings were perfectly clear.

This is not a good time to test milk, *I'm told,* for the cows are not in the right condition, here at least. We shall wait a few weeks, and then can make more tests, for there will be more milk.

I was so pleased with the result, and the boys certainly do take an interest in the work.

Very sincerely yours,
LAURA B. GELSER.

A FEW QUOTATIONS

"The love of rural life, the habit of finding enjoyment in familiar things, that susceptibility to Nature which keeps the nerves gently thrilled in her homeliest nooks and by her commonest sounds, is worth a thousand fortunes of money, or its equivalents."—*Henry Ward Beecher.*

" Instruction in agriculture properly presented, will increase interest in school life and in farm life. The care of stock, the protection of insectivorous birds, the preservation of game, the engineering of the farm, the great physical universe, will appeal directly to the boys, and the domestic science, including preservation of fruit, and dairying, and rural economy, will interest the girls. The farm is the groundwork, the backbone, the sinew, of our health, our wealth, our happiness. It must remain so. Keep close to Nature for physical, intellectual, and spiritual strength and growth."—*William K. Fowler.*

"The most successful farmers of the present day are those who work in harmony with the forces and laws of Nature which control the growth and development of plants and animals. These men have gained their knowledge of those laws and forces by careful observation, experiment, and study."—*C. L. Goodrich.*

CORNELL
Rural School Leaflet
SUPPLEMENT FOR THE CHILDREN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. 1. ITHACA, N. Y., FEBRUARY, 1908. No. 6

WHY IT SNOWS IN WINTER AND RAINS IN SUMMER

By W. M. Wilson

HOW many boys and girls remember that in our last lesson we changed the water in the teakettle into vapor or water gas by the heat of the fire, and then changed it back into water by using a cold glass? We thus proved that water exists in two forms—as a liquid which we can see, feel, and taste, and as a gas which we can neither see, feel, nor taste.

There is still another form of water, and that is the form we see most frequently in the winter time. Can you tell what this form is? If you place a dish of water out of doors on a cold night, what will happen to it? Try this, and you will then know that water exists in three forms,—as a solid, (ice), as a liquid (water), and as a gas (vapor). Can you think what it is that causes the same thing (water) to be a solid at one time, a liquid at another, and a gas at another?

Water begins to change to ice when it is cooled to a temperature of 32 degrees by the Fahrenheit thermometer. Fahrenheit is the name of the man who invented the kind of thermometers that are most generally used in this country. Ask your teacher to show you a thermometer and point out the freezing point of water which is 32 degrees above the zero mark on the scale.

If you want to know whether your thermometer is correct or not, you may easily test it by taking a pailful of snow and putting in enough cold water to make it slushy. Then stir the slush with the thermometer for a few moments. If the thermometer reads exactly 32 degrees, it is correct.

When we changed the moisture or vapor in the air to water by using a cold glass, the temperature of the air in the room was above the freez-

ing point which is 32 degrees. If the temperature of the air had been below the freezing point, the vapor would have been changed to ice instead of water.

Snow is made up of very small pieces of ice, and if the vapor in the air changes or condenses, as it is called, when the air is colder than 32 degrees, it snows; and if the change takes place when the air is warmer than 32 degrees, it rains. Thus, we see that it is the temperature of the air that causes it to rain in the summer, and snow in the winter.

I wish you might see a snowflake through a microscope. It is a beautiful sight. The illustrations show three snowflakes greatly enlarged. If you look at the frost on the window through a magnifying glass, you may be able to see some of the beautiful forms into which the moisture in the air crystalizes when it freezes.

FIG. 51.—*Snowflakes enlarged.*

MEMORY SELECTION

"The snow had begun in the gloaming,
And busily all the night
Had been heaping field and highway
With a silence deep and white.
Every pine and fir and hemlock
Wore ermine too dear for an earl,
And the poorest twig on the elm-tree
Was ridged inch deep with pearl.
From sheds new-roofed with Carrara
Came Chanticleer's muffled crow,
The stiff rails softened to swan's down
And still fluttered down the snow."

—*Lowell.*

BIRD STUDY

THIS year we want every boy and girl in the country as well as every boy and girl in the city to know birds. With very few exceptions birds are helpful to us on the farm and in the garden; they are a joy to us throughout the year. The boys and girls who make collections of birds' eggs, of feathers, and the like do not know birds. We are sure that every one who watches bird life and who learns the hardships and tragedies they have to meet, will do his part to protect birds through all the coming years.

We hope that every reader of the Cornell Rural School Leaflet will make some endeavor this year to attract and protect the birds. A sheltered home, abundant food, and pure water will encourage them to live near us. Many birds have been encouraged to inhabit bird-houses. This in itself is a proof that some birds need but to know that man is friendly in order to be willing to associate with him.

This is the month to make bird-houses. There should be one on every schoolground in New York State. Manual training classes will find the making of bird houses an interesting piece of work, and in rural districts where manual training is not yet taught, boys and girls will be able to make one, perhaps, without much help. Farm boys and girls learn to use their hands.

Birds which build in houses are wrens, blue-birds, tree swallows, martins, doves, piegons and sometimes chickadees. Birds will not make a nest in a house in which the doorway is too large. It should be made just large enough for the birds to enter, so that it will not be easy for enemies to get in to destroy the young. For the wren and the chickadee, the opening should be an inch, and for the other birds it should be about one and one-half inches. Only one opening should be provided for each house. A perch should be placed just below the door. Place the house on poles in somewhat secluded places. Martins and tree swallows build their nests about twenty-five feet above the ground; other birds usually prefer their home to be less than twelve feet. Newly made houses, particularly newly painted ones do not often attract the birds.

We shall be glad to know how many children throughout the State of New York make bird houses this year.

* * *

During the winter we have studied the nuthatch, brown creeper, chickadee, downy woodpecker, hairy woodpecker, and red-headed woodpecker. Probably many of you have not seen all of these birds, but you have the description of them, and will be on the lookout. Notice closely every little bird that you see. It will not be long then before you can

learn the names. It is always important to learn the names of out-of-door things, for names help you to learn facts about them from books.

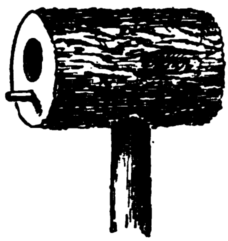

FIG. 52.—*A bird-house easily made.*

Before you receive the next Leaflet the birds will begin to come back. Many young persons think that birds go south because of the cold. The fact is they go south because in the north they cannot find food in winter. Birds feed upon insects and seeds, and the supply gets short during the cold winter. Just as soon as there is promise of spring in the air the pussy willow and skunk cabbage fortell it, and the birds know it. Therefore, I want you to be on the lookout for three that you may find between the middle of March and the middle of April: The robin, the bluebird, and the red-winged blackbird. The robin and the bluebird are familiar to every boy and girl and need not be described.

The red-winged blackbird is almost as large as a robin. It is black with bright scarlet shoulders. Mr. Chapman speaks of the coming of the red-wings as follows: "A swiftly moving, compact band of silent birds, passing low through the brown orchard, suddenly wheels and, alighting among the bare branches, with the precision of a trained choir breaks into a wild, tinkling glee. It is quite possible that in the summer this rude chorus might fail to awaken enthusiasm, but in the spring it is as welcome and inspiring a promise of the new year as the peeping of frogs or blooming of the first wild flower."

FIG. 53.—*An inexpensive bird-house. Note the roof.*

The red-wings nest in the marshes. In the October Supplement we showed you the picture of a red-wing's nest. Be sure to look for this "band of silent birds." Listen to their gleesome notes as they call "On-caree!" Who will be the first boy or girl in your school to see a bluebird? A robin? A red-wing?

"A day comes in the springtime
  When Earth puts forth her flowers,
Casts off the bonds of winter
  And lights him hence with flowers;
And then by marsh and meadow
  And by the silvery sea,
Goes up the red-wings' chorus:
  On-caree!"—*Dora Reed Goodale.*

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SUPPLEMENT FOR THE TEACHER.

ALICE G. McCLOSKEY, Editor.

Professors G. F. WARREN and CHARLES H. TUCK, Advisers.

Vol. 1. ITHACA, N. Y., APRIL, 1908. No. 7.

Lesson XXII

GARDENING

Fig. 64.—*At work*

"The garden is a lovesome thing, God wot;
Rose plot,
Fringed pool,
Ferned grot;
The veriest school
Of Peace;
And yet the fool
Contends that God is not;
God not?
In gardens; when the eve is cool!
Nay, but I have a sign.
'Tis very sure God walks in mine."

It is time to begin to think about gardens. This article may come before the teacher on a cold March day when the wind is blowing and the snow flying—when gardens may seem merely a dream of the past, and a doubtful promise of the future. Can any enthusiasm on the question be aroused at such times in the schoolroom? We believe it can.

There should be some instruction in the growing of plants in every schoolroom in this State. Gardening is recognized as one of the best all-round helps in the education of a child. Since this is the case, let us be active in strengthening this line of work in New York State.

I wish that there might be a well-organized school garden in connec-

tion with every city park and public school in the country. Gardening becomes a habit, and it is a very wholesome and healthful habit. If children begin young enough, and have some older person interested who can help them to make the growing of plants a success, they will spend more and more time in the work as the years go by. It will help to make them stronger and better men and women. It will be a resource for them through all the coming years.

The school garden should be a place in which children learn to know and to grow plants which they will afterward want about their own homes. Every garden in connection with a park or school should be a place in which children will be able to make a choice of the trees, shrubs, and garden crops that they would like to have on their home grounds.

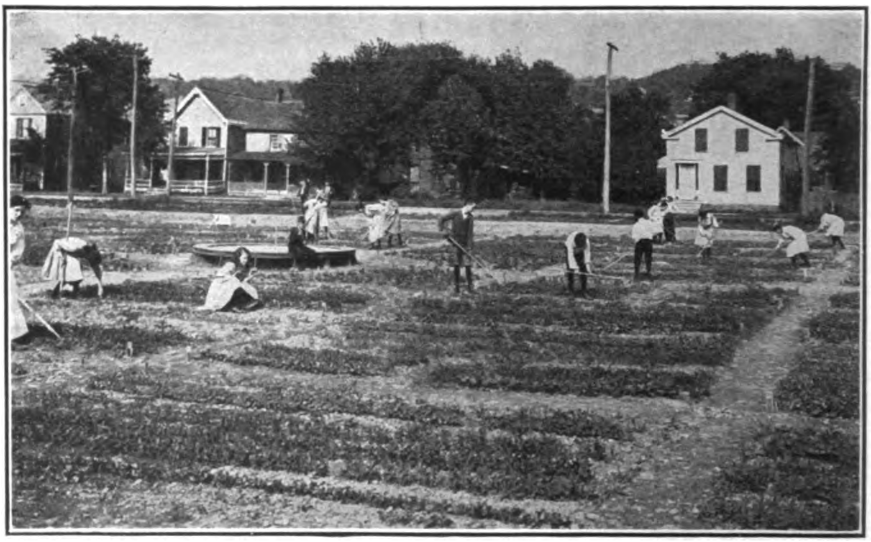

FIG. 65—*Ithaca school garden. The pond in the center is used for local aquatic life*

The public expense of such an enterprise would be small compared with the better citizenship it would bring about.

But the well-organized garden with competent gardener or teacher in charge is more or less of an expense in a community, and in all places the public is not sufficiently prepared to realize its importance and to support it. The day is coming when there will be gardens and play grounds in every community. Busy little minds and hands should not be *seeking* employment and amusement. It should be the duty of citizens to provide for the leisure hours of the children.

While waiting for opportunity to have the work of gardening conducted in a forceful way, let us do the best we can to interest children in growing plants, and in developing their school grounds. There is no better medium for nature-study than the garden, and any ambitious teacher can encourage her pupils to grow a few flowers or vegetables or experiment with farm crops. It need not be on an expensive scale. If the children do one thing toward it each year, the garden will grow.

Next month we shall give some specific suggestions for conducting garden work. In the meantime create enthusiasm for this subject by discussing trees, shrubs, and garden plants that might have an interest for the children. It would be well to have seed catalogs and leave them where the children can read them occasionally. The names of different flowers for a spelling lesson might be valuable in keeping the subject before the minds of the children. An occasional bit of poetry for a memory selection will help.

Again let me say that every teacher should do at least *some one thing* in garden-making this spring. In rural districts, discuss the question of experimenting with farm crops. Suggestions will be given in the April issue for definite experiments.

In the Supplement of this Leaflet there will be suggestions for growing sweet peas. This will interest the younger children. Doubtless some place can be found near the school in which sweet peas will grow.

Lesson XXIII

THE BEEF ANIMAL AND THE DAIRY ANIMAL

By H. H. Wing

Cattle are kept for two main purposes: For the production of milk and for the production of beef. These two purposes make quite different demands upon the vital energies of the animal. For this reason, by selection through many generations of those animals on the one hand that are best developed for meat production, and of those on the other that give the largest amount of milk, there have arisen two types more or less distinct in form and certain other characters; one known as the "beef form" or type, and the other known as the "milk form" or type.

It must not be supposed that these two types are entirely distinct or separate, for the cows of the beef type always give some milk, and animals of the dairy type will furnish beef of reasonably good quality when properly fattened. Then, too, while the types may be readily recognized in the best developed individuals of either, there are a great many animals of intermediate form that it would be difficult to assign to either type, since the two types tend to merge into each other by insensible gradations.

The chief differences in form that distinguish the beef and dairy types are:

1. In outline of body, especially as viewed from the side.
2. In depth and smoothness of flesh.
3. In size of udder and external blood vessels connected therewith.

In the beef form, the outline of the body approaches the rectangular. The general contour of the top and bottom lines is straight and parallel, and the general dimensions of the body approximate those of a brick; i.e., length twice the depth, and depth twice the thickness.

In the dairy type the general outline of the body is "wedge-shaped from before backward;" that is, the general contour of the top and bottom lines diverges from the front toward the rear. This is brought about by a relatively large development of the hind quarters and sometimes by relatively low and thin shoulders. The height of the animal at the hips is from one-half to one and one-half inches greater than at the shoulders. The wedge-shaped appearance is increased by a large and pendulous abdomen and by a large and well-developed udder.

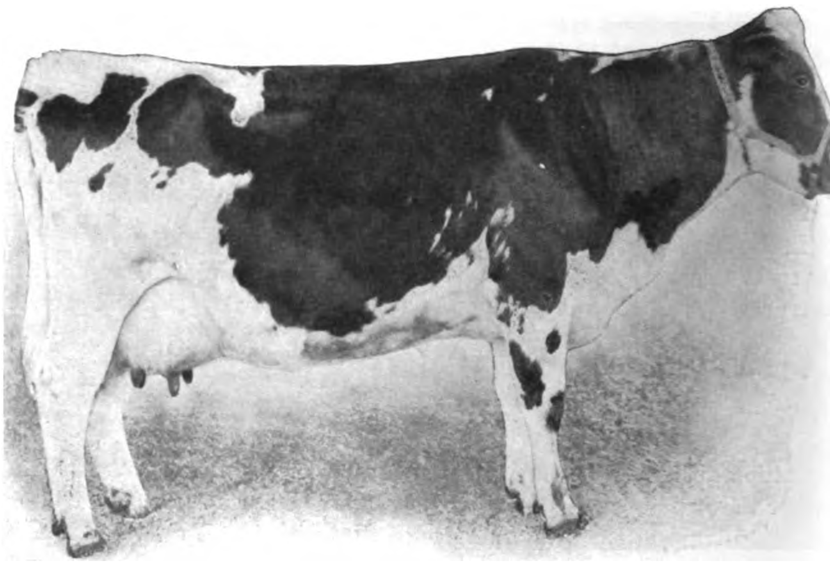

FIG. 66—*The dairy type*

In the best beef animal, even when not fully fattened, the whole body is thickly and smoothly covered with flesh (muscle) so that the angles of the bones are nowhere prominent. This is seen particularly over the upper portion of the ribs immediately back of the shoulder,

on the loins, in the thighs, and on the shoulder. The neck is short and blends smoothly into the shoulder and the whole body has a rounded appearance.

In the dairy animal, the lack of muscular development gives rise to a spare angular appearance. The angles and joints of the bones are prominent, particularly in the pelvis and the spinous processes. This does not mean that the animal is poor or emaciated for there may be abundant fat as indicated by a soft, pliable skin, and by rolls of fat in the fold of the skin in the flanks, and still the animal may present this spare appearance.

In the dairy type, the udder is, of course, much larger and fuller than in the beef type, and the so-called "milk veins" stand out prom-

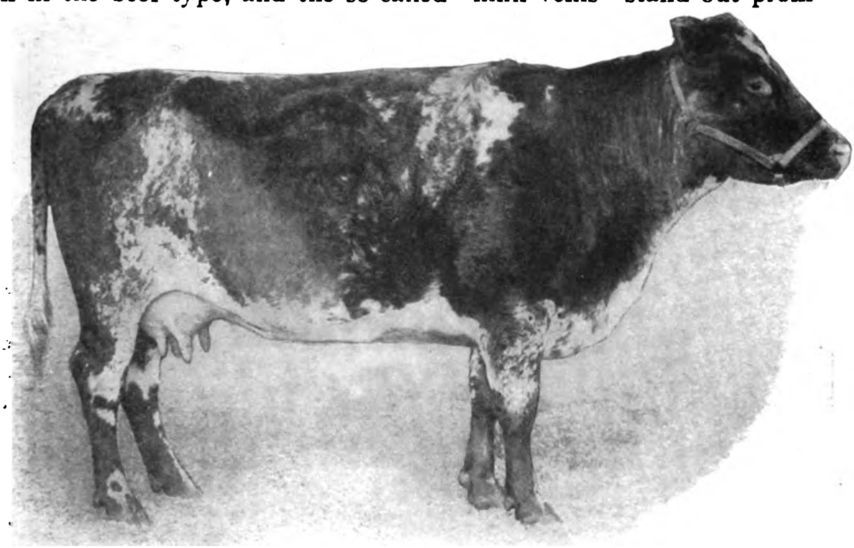

FIG. 67.—*The beef type*

inently on the abdomen, extending well forward to the chest. In the beef type, not only is the udder small and comparatively insignificant, but the exterior veins leading from it are small and more or less embedded in the surrounding muscular and fatty tissue.

Lesson XXIV

LESSON ON FEATHERS

BY J. E. RICE

Object.—To teach the pupil to know the name, shape, and size of the feathers which are to be found on each section of a fowl. This lesson is preparatory to the recognition of the different breeds of fowls.

Material.—(1) Two or more mature fowls, both male and female, from any breed or breeds.

(2) Suitable coop or coops with food and water.

(3) Drawing paper, pencils, and eraser.

(4) Blackboard and color crayons.

(5) An outline on the blackboard or on cloth or paper of a hen and of a rooster, on which is indicated the name of each feather section, and names of the feathers found there.

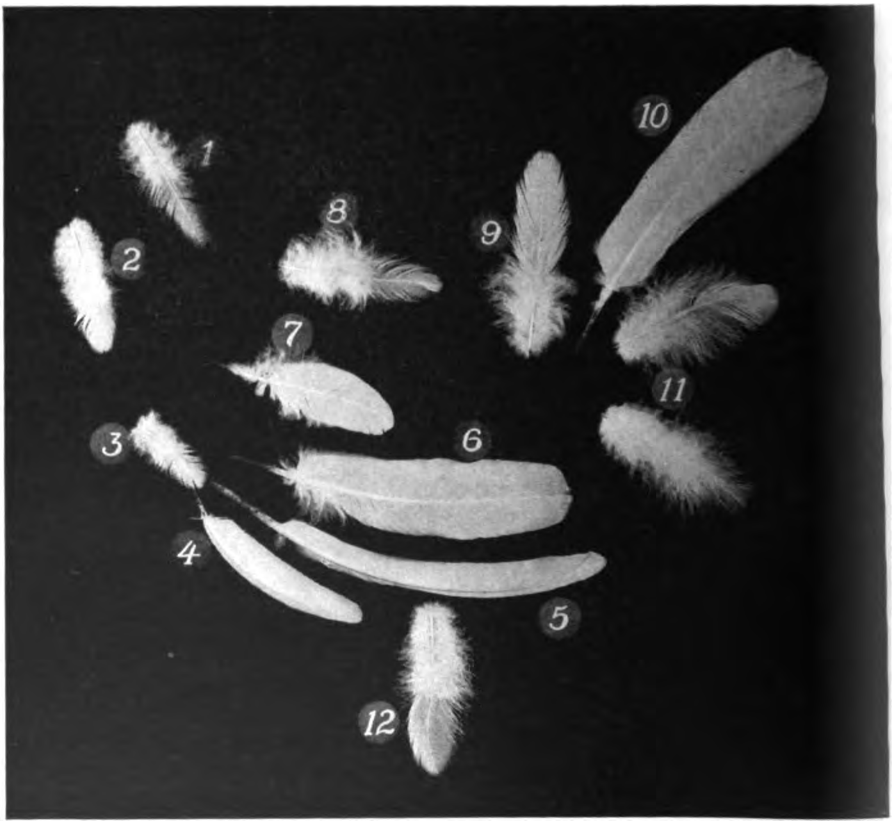

FIG. 68.—*The feathers of a hen, showing their relative size, shape and position. 1, Neck hackle; 2, Breast; 3, Wing shoulder covert; 4, Wing flight covert; 5, Wing primary; 6, Wing secondary; 7, Wing covert; 8, Back; 9, Cushion; 10, Main tail; 11, Fluff; 12, Thigh.*

(6) A small stand or table covered with burlap, carpeting, bagging, or other material which will make a rough surface, on which the fowl can stand with less danger from fright.

Method.—The lessons on feathers can be taught most successfully with the live fowl, which the pupils should be permitted to handle. They should see for themselves the kinds of feathers to be found on normally developed fowls. These they should compare with the feathers

which another pupil shows on the same section of another fowl of the same sex. The principle should be emphasized that the similarity between the feathers is not by chance, but that the feathers of the same size and shape will always be found on the same section of the same sex and same variety.

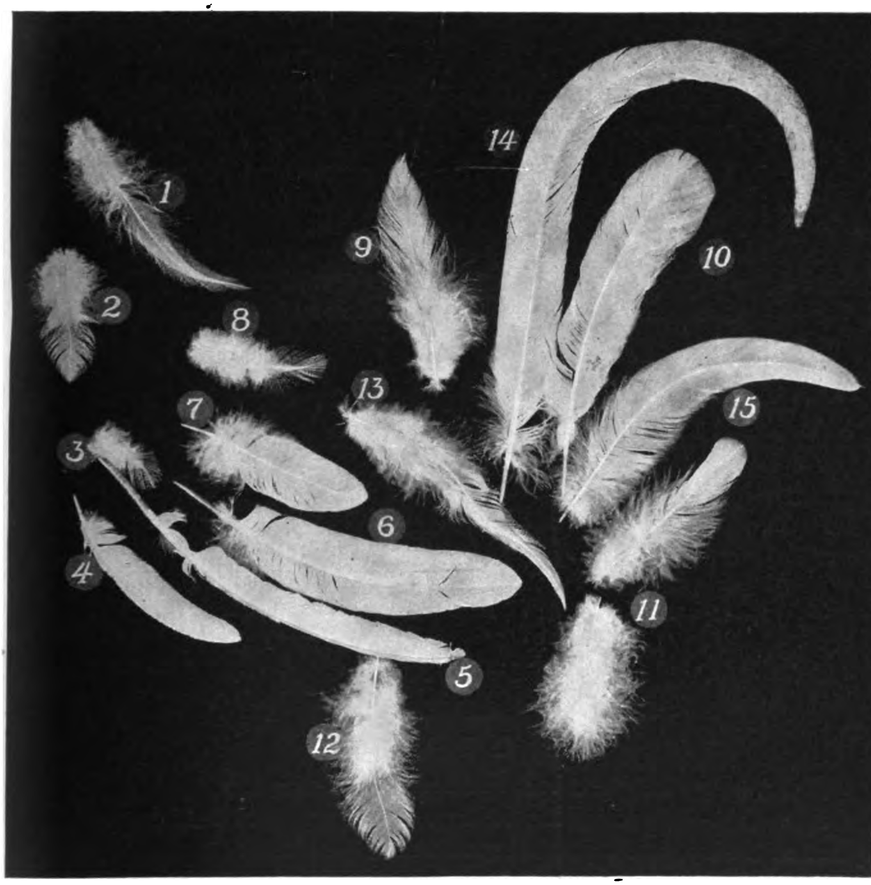

Fig. 69—The feathers of a cock showing their relative size, shape, and position. 1, Neck hackle; 2, Breast; 3, Wing shoulder covert; 4, Wing flight covert; 5, Wing primary; 6, Wing secondary; 7, Wing covert; 8, Back; 9, Tail covert; 10, Main tail; 11, Fluff; 12, Thigh; 13, Saddle hackle; 14, Sickle; 15, Lesser sickle.

Point out how the feathers from each section differ, in shape, size, and structure, from feathers on other sections of the same fowl. Call attention to the fact that this difference is always to be found in normally developed fowls.

Following are given the feather sections of a fowl both male and female, the name of the feathers to be found on each, and definitions:

Section.	*Name of Feather Section.*	*Definition.*
Neck	Neck hackle:	The long, narrow pointed feathers found on the neck of the male or female.
Back	Back feathers:	Short, broad feathers on the back.
Saddle	Saddle hackle:	The narrow, pointed feathers to be found overlapping the base of the tail on the male.
Cushion		The round-tipped feathers overlapping the base of the tail on the female.
Breast	Breast feathers:	Short, broad feathers covering the breast.
Tail	(a) Sickle feathers:	The larger flowing feathers of the tail of the male.
	(b) Lesser sickle:	The smaller flowing tail feathers which cover the sickles.
	(c) Main tail feathers:	The broad, flat, upright feathers of the tail.
	(d) Tail coverts:	The smaller flowing tail feathers which cover the main tail feathers.
Wing	(1) Primaries:	The large, stiff feathers on the first joints of the wings.
	(2) Secondaries:	The broad feathers on the second joint of the wing under which are tucked the primaries when the wings are folded.
	(3) Wing coverts:	The short, wing feathers overlapping the secondaries.
	(4) Shoulder feathers:	The short feathers overlapping the wing coverts.
	(5) Flight coverts:	The small feathers at the very point of the wing.
	(6) Wing bow:	The portion of the wing formed by the shoulder feathers.
	(7) Wing bay:	The portion of the wing formed by the secondaries.
	(8) Wing bar:	The portion of the wing formed by the wing coverts.
	(9) Wing points:	The portion of the wing formed by the primaries.
Body	Body feathers:	Medium sized feathers covering the body where not otherwise protected.
Fluff	Fluff feathers:	The soft feathers covering the abdomen back of the legs and below the tail.
Thigh	Thigh feathers:	Short, fluffy feathers covering the thighs.
Shank	Leg feathers:	The stiff feathers found on the shanks of feathered legged varieties.

Lesson XXV

ALFALFA

By G. F. Warren

Object.—To study the best methods of growing alfalfa.

Materials.—Three pecks of lime, one pound of alfalfa seed, one quart of barley, and a plat of ground 2 x 3 rods.

No crop is at present arousing more interest among New York farmers than is alfalfa. It is, therefore, the best crop to study. The students may be of use to the community if they learn whether alfalfa will grow in the neighborhood, and how best to grow it.

A ton of alfalfa is often spoken of as being equal in feeding value to a ton of wheat bran, because they have about the same composition. But it is always unsafe to compare a grain feed with a coarse feed on the basis of composition alone. The rough feed is harder to digest. Feeding trials at the New Jersey Experiment Station seem to show that alfalfa hay is worth two-thirds as much as wheat bran for the production of milk.

Co-operative experiments with many farmers in New York State have brought out the following facts about the growth of alfalfa:

1. A porous, well-drained soil is most likely to grow alfalfa successfully, but it sometimes succeeds on clay soils.

2. A rich, fertile soil is most likely to grow it successfully. Applications of manure are, therefore, desirable. Usually it is best to apply the manure the year before sowing the alfalfa, so as to have the weeds subdued, or they may be subdued by a summer fallow as given in No. 5.

3. Inoculation is absolutely necessary for success. On some soils this takes place naturally. If sweet clover or alfalfa have been growing in the neighborhood, this natural inoculation is more likely to occur. If inoculation does not take place naturally, the best way to inoculate is to take soil from an old alfalfa field.

4. The soil should not be acid. Alfalfa is more in need of lime than any other farm crop. About half of the trials indicate that lime is needed.

5. Weeds are one of the most serious enemies of young alfalfa. It is, therefore, desirable that a well tilled crop precede alfalfa. But if the manure and soil are not very weedy, this is not necessary. Weeds may be subdued by plowing early and continuing to cultivate the soil so as to keep them down, and then seeding late in summer. A light seeding of barley, one bushel per acre, is desirable if the alfalfa is sown in the spring. This is better than weeds because it dies when cut for hay.

Which of these treatments is necessary on any particular farm can only be told by trial.

If the school has land available, make the following experiment. In most cases, it will probably be better for the students to carry it out at home. Perhaps it can be carried out on farm land adjoining the school grounds, and have all the work done by the students. Plats 5 and 6 could be omitted unless some student volunteered to sow them at the proper time.

Lay out a plot 2 x 3 rods, and divide it into plats of a square rod each, as in the figure, and drive a stake at each corner—twelve stakes in all.

1	3 Inoculated	5 Inoculated
2 Limed	4 Limed and inoculated	6 Limed and inoculated

Apply 3 pecks of lime to plats 2, 4, and 6. Sow soil from an old alfalfa field on plats 3, 4, 5, and 6. A few quarts will be enough for this area. Two bushels will be enough for an acre. Sow one quart of oats or barley and two-thirds of a pound of alfalfa on plats 1, 2, 3, and 4. Do not let the grain ripen, but cut it for hay so that it will not injure the alfalfa. Keep the soil on plats 5 and 6 stirred so as to prevent the growth of weeds until the last of July, then sow the remaining pound of alfalfa alone.

FIG. 70.—*Alfalfa.*

If a larger area can be used, the same experiment may be carried out on any sized field. The plats may be of any size.

Problem; How many pounds of alfalfa seed would be required for one acre at the rate here sown? How many bushels of barley? How many bushels of lime?

FARM BOYS' CLUB

We want the assistance of every teacher in the country to help boys to a knowledge of agriculture. If a teacher has no time in her school to give instructions in agriculture, perhaps she can help the boys in her district to organize an agricultural club in connection with the New York State College of Agriculture. They will be sure to get valuable suggestions from Professor Tuck who has the matter in charge. He is anxious to help strong, active young fellows in farm districts to get their minds and their muscles close to a piece of work that will be not only educational but profitable and entertaining.

How many boys are there in your district who would like to join the Boys' Club? Let us know the number, and we shall send membership blanks. The following letter to the boys explains the purpose of the club:

MY DEAR BOYS:

It will not be very long until spring. You boys know that wonderful changes take place then. Now, everything is frozen and dormant. The trees seem to be dead and the soil lifeless, but in a little while a change will come to both trees and soil. They will take on new life in preparation for another season's usefulness. Did you ever think that we can take a hand in this changing life—that we can do things with our hands in co-operation with nature which will bring us interesting and profitable results?

We are all used to the regular chores on the farm. We have all helped our fathers in the fields. We have often found it hard work. Our backs became tired, our hands were blistered; all in a kind of work that we did not like.

Now, I want to ask your advice. What do you think of our planning to have a "little farm" of our own? John, suppose you ask your father for a quarter of an acre on which to plant your own corn, and, George, suppose you speak to your father about another quarter of an acre for growing your own potatoes. Then perhaps James is interested in the cereals as wheat, oats, buckwheat and the rest.

"Well," you say, "what is the good of all this? I have enough work to do without taking up this 'little farm.' " Now, just a moment! This is not going to be all work. There is going to be some play. How would you like to form a club of young farmers, asking in the other boys around the neighborhood who would like to start a "little farm?" Let us have meetings once in a while to go over the plans for the spring, and then after our crops are in, talk over plans as to how to take care of them best and market them. Now do not forget that we are going to market these crops ourselves, and of course the proceeds will all be ours. What boy will get the best results from his farm this summer?

Yet this is not all. You have seen your father or your neighbors exhibit produce at the County Fair. Why cannot you and I exhibit there? Your County Fair Association would be glad to make room for an exhibit of farm products raised on these "little farms" by this band of young farmers. A great many premiums will be offered for this work, so that George or James may not only manage his own plot of ground, sell his own crops, but exhibit at the Fair, possibly winning first prize on his corn, second prize on his potatoes, and establishing a reputation through that country as having for sale the best seed corn and seed potatoes.

But we will not stop at simply exhibiting at the Fair; we want to get some more fun out of this work. Suppose that we ask the County Fair Association to plan one day for the young farmers when we can get

together for a great picnic and plenty of interesting games. We will talk about this later.

Now, boys, what do you think about this? Would you like to form an agricultural club in your school to carry out some of these ideas? Talk to your teacher and your parents about this.

Yours for the Boys' Club,

CHAS. H. TUCK.

FARM GIRLS' CLUB

There is to be a Farm Boys' Club in New York State, and we feel that there should be a club for farm girls. The purpose of this club is to help girls along the line of home-making.

Instruction will be given in cooking, sewing, and the like, and there will be opportunity for girls to show what they have accomplished at the county fair, and at the state fair. The girls in many states in this country have done splendid things along these lines, and we know that our New York state girls would like to stand first in the desire to know how to make the rural home more attractive and helpful.

Girls between the ages of ten and eighteen who wish to become members of this organization should ask their teacher to apply for membership blanks for them. They will be associated with thousands of other girls in the state, members of the same club.

CORNELL
Rural School Leaflet
FOR THE CHILDREN

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. 1. ITHACA, N. Y., MARCH, 1908. No. 7

GARDEN NOTES

By C. E. Hunn

"Here are Sweet Peas, on tiptoe for a flight,
With wings of gentle flush o'er delicate white,
And taper fingers catching at all things
To bind them all about with tiny wings."—*Keats*.

All our boys and girls should have gardens this year. In the next issue of the Leaflet we shall make suggestions for these gardens, and I believe everyone will want to grow something.

But before our first real garden lesson, we may be able to plant sweet peas; and, since no garden is complete without these attractive blossoms, we must be sure to sow the seeds on time. The following directions will help you:

1. Sweet peas should be sown as early in the spring as the ground can be worked. They often do well, however, if sown as late as the tenth of May.

2. In *heavy, wet, cold soil*, the earth should be removed to a depth of from ten to twelve inches. Fill this trench within five inches of the surface with light, garden soil. This should be mixed with wood ashes at the rate of one quart to two bushels of soil, or with well-rotted barnyard manure, in a proportion of one peck to two bushels of soil. Firm this down by treading, and sow the seeds thickly. Fill the trench even with the surface, or place two or three inches of soil over the seeds, filling in with soil as the young plants grow.

3. In *light soils*, the upper five inches may be removed, the ashes or the manure worked into the bottom of the trench and the seeds sown.

4. The roots of sweet peas should be kept cool. Through the hot summer months, spread coarse manure, short grass, or straw along the rows to hold the soil cool and retain moisture.

5. As soon as the plants begin to run or climb, make supports for them with chicken wire or brush. A trip to the woods for underbrush would make a good nature-study excursion, and a very attractive support might be found for the sweet peas.

6. If the season is dry, thoroughly soak the soil once each week.

7. Gather the blossoms as soon as they open, and you will prolong the season of blooming.

8. In planning for a place for your sweet peas be sure that you do not put them in the middle of a piece of ground. They will look far better if they have a background. Sow the seeds, therefore, near a fence, if there is one in your schoolyard. Remember that flowers need a background. Later in the year you may be able to plant some kinds near the building.

As soon as possible ask the teacher whether you may have a cleaning-up day, so that you may put the schoolyard into neat condition. You can bring rakes from home, and I am sure you will enjoy getting rid of all old rubbish, sticks, and stones that make many schoolyards unsightly.

BIRD NOTES


FIG. 62.—*Meadowlark.*

Not far away there is a large open field in which some time during the month of March I shall hear the flute-like notes of the meadow lark. His song is clear and ringing and very sweet. I associate this meadow bird with the first smell of the earth, with the first touch of green in the landscape, and with the gold of the dandelion. As soon as I think the little songster has come, I shall follow the path through the meadow hoping to hear him sing.

Let us take the meadow lark as one of the birds for study this month. We shall also try to learn something about cowbirds, and more about the bluebird. In looking for these birds you will be sure to see others and hear their spring songs. I shall, therefore, give a list of the birds comprising the spring migration, so that you may begin to take an interest in all of them. The only way to know birds is to watch and listen whenever you are out of doors. If you see one this spring that is unknown to you, study it carefully. Look over the list of the spring migration given below, and try to find descriptions of the birds in some book on the subject. Always make your field observations accurately as to size (compared with the robin), color, manner of flight, and the like. You will be better able to compare the bird with the printed descriptions.

So much has been written on the common birds that anyone willing to study can receive help in becoming familiar with them. I know a boy eleven years old who knows nearly all the birds in his vicinity, and there are many. He gained his knowledge by accurate and patient observation in the field, and by consulting Chapman's *Bird Life,* and *Handbook of Birds,* published by D. Appleton & Co., New York city; and Neltje Blanchan's *Bird Neighbors,* published by Doubleday, Page & Co. You may find these books in your school library. If you are in a rural school, perhaps the teacher will have one of them on her desk, so that you may consult it. Every farm boy and girl should know birds, and the more intimately you are acquainted with them the greater will be your joy in the springtime. Then, too, many birds are beneficial to the farmer, and they should be known and protected by him. Let farm boys begin.

FIG. 63—*Cowbirds.*

List of Birds Comprising the Spring Migration.
(Until April 20—Approximate.)

(Taken from Chapman's *Handbook of Birds of Eastern North America.*)

DATE OF ARRIVAL		DATE OF ARRIVAL	
Feb. 15–Mar. 10	Purple Grackle	April 1–10	Great Blue Heron
	Rusty Grackle		Purple Finch
	Red-winged Blackbird		Vesper-Sparrow
	Robin		Savanna-sparrow
	Bluebird		Chipping-sparrow
Mar. 10–20	Woodcock		Tree swallow
	Phoebe		Myrtle Warbler
	Meadow Lark		American Pipit
	Fox sparrow		Hermit Thrush
	Cowbird	April 10–20	Yellow-bellied Woodpecker
Mar. 20–31	Wilson's Snipe		Barn swallow
	Kingfisher		Yellow Palm Warbler
	Mourning Dove		Pine Warbler
	Swamp-sparrow		Louisiana Water Thrush
	Field-sparrow		Ruby-crowned Kinglet

SPECIAL STUDY

Meadow Lark

Description.—Length 10¾ inches, a little larger than a robin, black, brown and buff on the upper parts; yellow beneath; a black crescent on the breast; sides streaked with black; outer tail-feathers white.

Observations.—1. Meadow larks often try to escape observation by hiding in the grasses. The colors of the back protect them best in this position.

2. Note how rapidly they fly. Observe the white feathers on either side of the tail.

3. The song is flute-like, clear, and ringing.

Cowbirds

Description.—Nearly 8 inches long. The head and neck of the male are dark coffee brown, the rest of the plumage is a glossy greenish-black. The female is a brownish-gray with whitish throat.

Observations.—1. Cowbirds appear singly or in small bands. They are often seen feeding near cattle.

2. The females lay eggs in the nests of other birds. I have found a cowbird's egg in the nest of a red-eyed vireo. Since vireos are smaller than cowbirds, their young often die of starvation, because the young cowbird demands so much food. Vireos are more valuable than cowbirds and it is a pity that they should be imposed upon.

3. The eggs of the cowbird are white, speckled with cinnamon brown or umber.

Bluebird

We hope that boys and girls have made boxes for the birds, and that bluebirds will nest in them, since they are very interesting to watch. It has been said that a box for bluebirds should not have any threshold or place to alight. Bluebirds do not need it, and sparrows do not care for a place without a threshold. If this is the case, the absence of a threshold might prevent sparrows from disturbing the bluebirds. It may be well to experiment with this and find out whether it is true.

Barbed wire placed around trees and posts will prevent cats from reaching the nests of the birds. It is very important that all young persons should realize how very destructive cats are to the birds. During the nesting season they should be prevented from roaming about, particularly at night. In one garden I have known two or three entire bird families, mother and young, destroyed in a night by a prowling cat.

CORNELL

Rural School Leaflet

SUPPLEMENT FOR THE TEACHER.

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey, Director.

ALICE G. McCLOSKEY, Editor.

Professors G. F. WARREN and CHARLES H. TUCK, Advisers.

Vol. I. ITHACA, N. Y., APRIL, 1908. No. 8.

GARDENS

By Alice G. McCloskey

"When proud-pied April, dressed in all his trim,
Hath put a spirit of youth in everything." —Shakespeare.

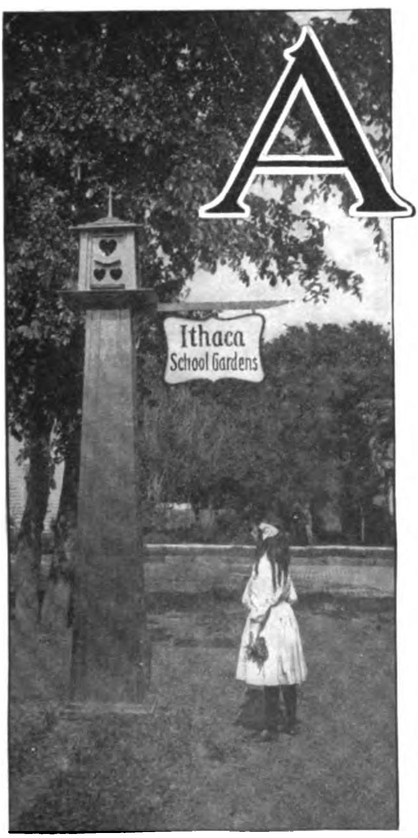

Fig. 71. *Entrance to the Ithaca school-garden*

A garden is one of the best means of interesting children in out-of-door life during the coming months. In this Leaflet we shall suggest ways to conduct gardens in connection with schools. Gardens in urban and suburban communities will be of different types and conducted in different ways from those in rural districts, but there should be gardens in some form in connection with every school in New York State. If there is no place about the schoolhouse for a garden, the inspiration and instruction can be given in the schoolroom for growing plants on the home place. Gardening is a habit. If young persons are taught to garden intelligently during the first five years of school life, they will, in all probability, care to garden the rest of their days.

Many persons have failed in school-gardens largely because they did not give sufficient thought and preparation to this important piece of educational work. Some enthusiasts undertook the enterprise

because it was a new feature in education, and was more or less interesting to the public. But when, however, there was realization of the labor necessary to keep a piece of ground in cultivation, and the amount of effort needed in the beginning to keep the children interested, there was not enough enthusiasm left to investigate the cause of the difficulties, and overcome them.

Very often too much is attempted the first year. Some very attractive school-gardening work has been done on large pieces of ground with hundreds of children. The persons who have made a success of this work have had deep belief in its value, and much perseverance and time have been given to develop the enterprise. Noting their success, many teachers have endeavored to follow their example, and have tried to have children cultivate some large piece of ground, difficult perhaps to work, and failure followed. It were far better to make very small beginnings, teaching children to cultivate a few plants well, than to have them undertake too much without knowledge or energy to complete what they have begun. This, I think, at the outset is most important, *very simple beginnings in gardening in connection with school work.*

But make a beginning. Whatever the hardships, it is worth the while, if for no other reason than to give the children the resource that love of gardening brings into their lives. Do you think that gardening is a wholesome and healthful thing for little children, for their bodies and their minds? If so, give the young persons in your community, whether in the country or the city, this opportunity for development. Do not be discouraged if those who sit by the wayside question your success. Some persons will expect to see the children carrying baskets of flowers to the hospitals at the end of the first year; they will expect the garden to be a thing of beauty, free from weeds. Do not be discouraged if you cannot accomplish all this. If a fair start is made in the first year, time will bring about desired results. Each year the work will grow stronger; each year the garden can be more profitably cultivated; each year the children's love of the soil and the green things growing will increase.

Let us first consider a school-garden under favorable conditions. There is a piece of ground, a half-acre, perhaps, in extent, not far from the school. This ground is at the service of the teacher and the children. The problem before them is to make it a productive piece of property, to give the greatest educational value possible per square foot. The proper handling of this work ought to bring about definite educational and social development for the children. Following are some of the factors that should be considered in this development:

1. *Civic pride.* Every citizen should consider what part he can take

in making his city more attractive and more desirable in every way. The children should begin to think of these things. Before the piece of ground is touched, they should be given an opportunity to discuss the condition of the property and make suggestions for its improvement. The school-garden should be one of the most marked demonstrations of civic betterment.

2. *Order.* A school-garden should be an expression of orderly arrangement. If the children are very young, the ground should be prepared and staked before they begin work. With older boys and girls, however, it is well to let them do everything possible in connection with the development of the grounds. Give the children everything that you can to make the ground look orderly: the stakes should be the same size, twine the same quality and color, measuring lines the same, and the like. In a garden connected with a settlement, I was told that the children cut the strings separating the plats, that they pulled up the stakes, and were generally destructive. I looked over the piece of ground, and was not surprised that this had taken place. The stakes were made of any available piece of wood that could be picked up, and the plats outlined by strings differing in kind and color, so that the appearance of the place was not such as to demand respect. As soon as the ground was properly laid out, the children had an appreciation of its neat, orderly appearance, and there was no further destruction.

3. *Landscape design.* It is not sufficient that a piece of property should be neat and planned for utility. It should be developed along the lines of good landscape design. Any teacher who has this proposition before her should, if possible, consult a landscape gardener in regard to her plans. It is much better to have the garden properly laid out in the beginning than to try to make changes after its development has begun. The plan of the grounds, the situation of tool house, pond, and the like, and the planting in the garden, should be decided before the ground is touched. The older children will receive valuable lessons in drawing up the plans and locating the different places that

will make the grounds more useful and attractive. They should make maps of their own plats, marking the kinds of plants to be grown, distances between rows, etc. Teachers in New York State may receive help in planning their school-gardens by consulting the Professor of Rural Art. Address, Prof. Bryant Fleming, College of Agriculture, Ithaca, N. Y.

4. *Architectural features.* Every school-garden should have a tool house. There should be a shelter. There should be some sort of entrance to the grounds marked by a signpost or archway. These architectural features should not be put up in a hit or miss fashion. Any architect in the community will be willing to suggest plain structures that have good architectural lines. Such features will be educative, since the children must see them every day. The signpost illustrated on the first page, designed under the direction of Professor Fleming, has been a means of pleasure and education to the children of the Ithaca schools.

5. *Planting.* From the very first the children should be consulted regarding the planting of the school-garden. They should feel that with patience and perseverance this piece of ground could be made a thing of beauty and civic pride within a few years. The school-garden should be a place in which children will become familiar with plants that they will later grow on their own home gardens.

6. *Life.* The school-garden affords the best opportunity for general nature-study. Here the children come in contact with plant and animal life, both beneficial and injurious. They should be given some knowledge of insect life in connection with the garden, that they may be ready to make observations as the season advances.

7. *Inquiry, accuracy, patience, perseverance,* and *courage in times of adversity* may all be developed in a school-garden. The most should be made of this opportunity for strengthening children along these lines.

8. *Results of labor.* This can be demonstrated clearly in school-gardening. Careful work is rewarded. On our school-garden at Ithaca this point was very clearly demonstrated to the children in many ways, but one in particular comes to my mind. The tomato plants which were used in their gardens had been grown in individual pots. The children made selections for their gardens from several hundred plants, and were taught which were most likely to grow into productive plants. They were cautioned to put the plants into the ground in the most careful way, not interfering with the root system any more than necessary, and firming the ground well about the plants. They followed directions carefully. A few days later there was a severe frost which killed many plants in the neighborhood. The children lost but twelve out of the

four hundred, probably due to the strength of the plants and the care with which they were set out.

9. *Thoughtfulness for neighbors.* Oftentimes children are antagonistic toward each other largely because they have had no one to help them to a better point of view. With the right direction, it is not difficult to have them develop a sense of justice. On the school-garden there is ample opportunity to realize that carelessness in regard to their own property often causes their neighbor inconvenience.

10. *Generosity.* A little talk with the children as to what they will do with their crops will often suggest to them some pleasure they can give to others. This should be encouraged. I have known some children who took more delight in giving flowers and vegetables away than in keeping them. All children are imitative, and in a community such as a school-garden, one generous spirit often encourages a like spirit in others.

11. *Entertainment.* If the teacher in charge of the school-garden will help the children to give a reception on the grounds, at which they can entertain their parents and friends, it will be valuable to them in many ways. In preparation for such a function, teachers will have an opportunity to give instruction in some social forms that will be helpful to the children in future life.

Some Things to Consider in Conducting School-Gardens

1. *Organization.* A good-sized garden for children must be well organized. Everything should be worked out carefully before the time of planting, since confusion defeats the purpose and progress of the work. In handling large numbers, time should be taken for drill in the discipline of the garden. This will be very helpful through the entire season. Teachers will find that a whistle will save their voices. This can be used as a signal, the children learning the meaning of the different number of times it is blown. Obedience is much more easily obtained out-of-doors than in the schoolroom. The children are more cheerful and seem willing to conform to all that is necessary to make the garden a sucecss.

2. *Size of plats.* In staking out the ground, do not make the plats too large. Children become discouraged if they have more to do than they can do well. I have found that a plat 8x10 feet occupies all the time that the average school-boy of ten or twelve years cares to give to gardening. If, however, the children take the plat for commercial purposes, they may be successful in cultivating a larger piece of ground.

3. *Class garden.* Satisfactory results have been obtained by having the entire class take charge of a piece of ground, each having a share in planting a row or part of a row. The children work together, and the harvest is used for any purpose that the children as a class desire. In this way a small piece of ground can be made useful for a large number of children.

4. *Tools.* The tools should be ordered early in the season. We have found in our gardens that the small-sized hoes and rakes of good quality have been more satisfactory than large ones for most work. The children can handle them more easily and in the close culture of small plats they are more convenient. We secured our rakes and hoes for twenty cents apiece. We have used them for two years and they are still in good condition. At the close of every exercise tools should be cleaned and hung in the tool house.

5. *Seeds.* If a large piece of ground is to be cultivated by the children, it would be well to secure the seeds in bulk. Some of the older children will enjoy putting them up in packets and marking them. This will be a good school exercise. The teacher with some of the children might estimate the number of linear feet to be planted with each kind of seed. If the teacher does not know the quantity needed for this estimate, the seedsman will tell her. If there are but a few children in the school or a small piece of ground to be cultivated, the penny packets will be found satisfactory. These can be purchased of James Vicks' Sons, Rochester, N. Y.

6. *Testing seeds.* Children should acquire the habit of testing seeds which they purchase. This may be done in the following way: Take a five-cent cake tin. On the bottom place a layer of cotton wadding to absorb and retain the moisture; over this place a sheet of moist blotting paper marked off in squares, each square labeled with the kind of seed to be tested. Place another blotter over the seeds, and cover the tin with another of the same size, or a thin board. Place the tester in a warm room and keep the blotters moist.

7. *Market.* The handling of produce opens a large and interesting field along educational lines. If children wish to sell their products, they should learn that it is always important for the market gardener to present his produce to the public in the most attractive form. Some children make the baskets during the winter in which they are to exhibit their garden products. Some day there may be market places in villages and cities for the crops grown in children's gardens. This would add greatly to the interest the children would take in their harvests. Such an enterprise would encourage industry, and appeal to many idle

boys. Since, as Superintendent F. D. Boynton said recently, "Our prisons are houses of detention for energy gone wrong," some concrete business enterprise for boys and girls in the community might decrease the number of jails and reform schools. The garden with a good market will help.

8. *Wild gardens.* In some schools the children have very interesting wild gardens. A piece of ground has been selected for this purpose, the soil enriched with earth from the wood, and as the years pass the children have added to the number of wild plants. Wood plants should not be transplanted while in blossom. If the teacher will take her pupils to the woods some day in spring and mark the wild plants by means of a piece of wood strong enough to resist the storms of spring and summer the children may dig up the soil in this place and in the fall the root of the wild plant may be obtained. One school in this State is trying to have specimens of all the wild flora in the vicinity. *The children should always be cautioned against exterminating wild flowers.*

9. *Old-fashioned flowers.* The children of the Ithaca schools enjoyed laying aside a part of a piece of ground for a grandmother's garden. In this were grown the following:

Ice Plant	Venus' Looking Glass (blue)
Marigold	Fenzlia dianthiflora
Pansy	Musk Plant
Portulaca	Cockscomb
Morning Glory	Mignonette
Calliopsis	Double Feverfew
Gaura	(Prince's Feather)
Tall Zinnia	Trumpet Flower
Clarkia pulchella	Globe Amaranth
Catch Fly	Petunia (single white)
Shell Flower	Sunflower
Love-lies-bleeding	Love-in-a-mist
Godetia Whitney	Viscaria oculata
Rose of Heaven	Lady Slipper
Four O'Clock	Pot Marigold
Sweet Sultan	Bachelor's Button

10. *Observational plats.* Many children in villages and cities do not know how the common grains look in the field. It is a good idea to have observational plats on the school-garden, growing grains, and some of the more important economic plants that are used in some form by

FIG. 72. *A band of gardeners*
(Mr. Edward Mahoney, Yonkers, N. Y.)

nearly all persons. In a school-garden in Chautauqua three kinds of oats differing in quality were grown, and the children had an opportunity to observe the value of selected seed. This gave an opportunity for discussion along the line of plant breeding.

11. *Borders.* Some place in the school-garden should be laid aside for an attractive walk, flower-bordered on either side. In our garden at Ithaca we have the entire grounds flower-bordered. The entrance marked by a signpost leads along a path eight feet wide and seventy feet long used as an approach to the tool house and assembly arbor. (Fig. 75). This path has a border on each side in which last year were grown the following: Nasturtiums, bachelor's buttons, marigolds, zinnias, larkspur, and sunflowers. The lowest-growing flowers, the dwarf nasturtiums, were planted near the walk, the other flowers grading in height up to the sunflowers. All of these plants were easily grown and furnished flowers throughout the season.

12. *Shrubs.* The first year the children should discuss at least one shrub. Children like a touch of color, particularly red. I would suggest, therefore, that each school try to secure a crimson rambler rose, which

may be purchased from any nurseryman. This would give a bit of cheery color along the country road.

In ordering a crimson rambler rose, ask for two year old plants. If obtained in the spring, dormant plants should be secured, and when received, the roots should be cut back at least one-half. In planting roses care should be taken to set them in good, strong, rich, well drained soil. If the soil where they are to be planted is poor, it should be removed and new soil containing well-rotted manure substituted. Set the bush down to the level of the lower branches and firm the soil around the roots. Any location except a direct northern exposure will prove suitable. Very little care is needed to have a good specimen plant. Train and fasten new growths, and each year supply a small quantity of rotted manure to the roots.

13. *Arrangement of flowers.* To arrange flowers artistically is a study in itself. A person of good taste is frequently annoyed on entering a home to note the way in which flowers are placed in vases. Any person who has the management of a school-garden should get as much information as possible in regard to arranging flowers. Combinations of flowers should be taught. Some cut flowers look best by themselves, while the beauty of others is increased tenfold by combining with some other blossoms or bit of green. Have you ever arranged sweet peas with

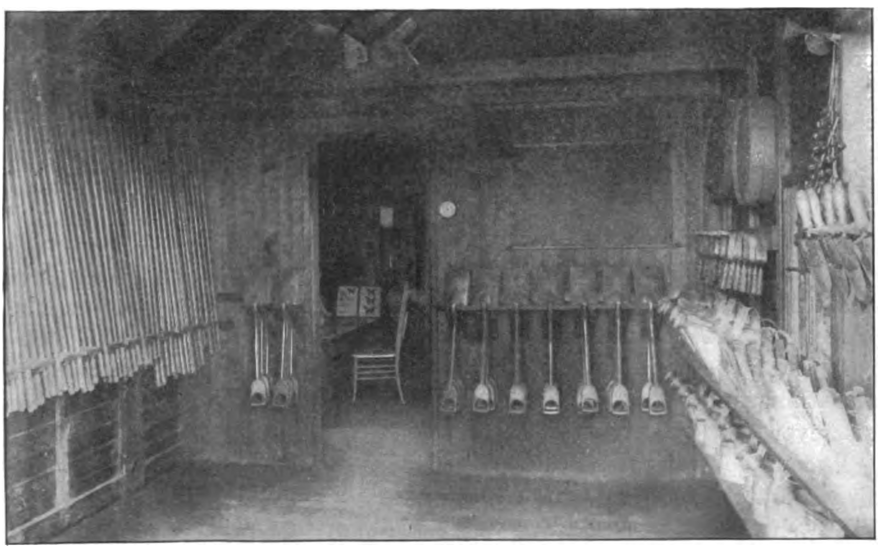

FIG. 73. *A neat tool house*
(Mr. Edward Mahoney Yonkers, N. Y.)

gypsophila (infant's breath)? Have you ever taken the black-eyed-Susans from the field and arranged them in a bowl with the common sensitive fern? Have you ever arranged red poppies with oats?

14. *Flowers of field and wayside.* If I were teaching in a rural school I should discuss with the children ways in which we could use some of the common field plants for decorative purposes. Clovers, daisies, buttercups, black-eyed-Susans, goldenrods, asters, ferns, wild lupine, timothy, wheat and the like might be used for borders, and from these one would be able to gather good combinations for arrangement in vases for the home and school. Field plants are aggressive, but they can be controlled by removing the seeds.

"And forth into the fields I went,
And Nature's living motion lent
The pulse of hope to discontent.
I wondered at the bounteous hours,
The slow result of winter showers;
You scarce could see the grass for flowers."
—Tennyson.

15. *Sun dial.* Sunshine and shadow give material for many nature-study lessons. Sunlight has to do with gardens. The sun dial offers outdoor interest and would be desirable in the schoolyard.

16. *Playground.* Some day there will be a playground in connection with the school-garden. Play should be directed. Would it not be possible to have a playground in every community, in which there would be some swings, a May-pole, a tether ball, a see-saw, and the like? Would children in the neighborhood be attracted to such a place?

HOME GARDENS

The public garden, whether on school grounds or vacant lots or in parks, should be the place in which children receive intelligent instruction in the growing of plants, that their knowledge may be used on the home grounds. On the school-garden should be grown types of shrubbery and flowering plants, as well as vegetables, that children may learn something of them, so that they will be able to utilize their knowledge wherever they may be in after years.

Encourage every child to have a garden at home if possible. There they should plant the things they want to grow, vegetables, flowers, vines, shrubs, or trees. With very little effort a teacher would be able to get the children interested in growing at least one or two things the first year. In the Ithaca schools thousands of penny packets of seeds

are given out in the spring, and the children seem to have an increased interest in buying them as the years go by.

In some communities the civic improvement society encourages the children in gardening by offering prizes for the best home gardens. A committee is appointed to visit the gardens and to take sufficient interest in them to be able to judge the merits of each at the close of the season. It would be difficult for the public school teacher to take this extra work, since visiting the gardens would necessarily demand a good deal of time; but if the civic improvement society will work with the public schools, the teachers will be willing to give their co-operation. If the season's work is closed by a flower and vegetable show, it adds greatly to the interest.

The most successful work in home gardens that has come under my observation, has been under the direction of Mr. H. L. Drummer, of Bath, N. Y. The children in Steuben county have become enthused, and anyone who will attend the ninth annual exhibition of the Steuben Nature Study Workers, September 29 to October 1, will realize that a most excellent work is in progress. The teachers and parents in the county have worked with Mr. Drummer, and the results he has obtained show that he has deserved their confidence and co-operation.

"The year's at the spring
The day's at the morn;
Morning's at seven;
The hill-side's dew-pearled;
The lark's on the wing;
The snail's on the thorn;
God's in his heaven—
All's right with the world."

—Browning.

"Such a starved bank of moss
Till that May-morn,
Blue ran the flash across;
Violets were born."

—Browning.

RURAL SCHOOL-GARDENS

In the foregoing pages we have given suggestions for gardens in villages and cities. Many of these suggestions can be used in connection with rural schools, but it will not be possible to organize such gardens in country places. We hope that every rural school teacher will consider the preceding suggestions, and use as many as she deems wise on her school grounds.

The rural school-garden will have a character all its own. It will be, in a way, a small experiment station; a place in which investigation of problems interesting to the farm community in which it stands can be conducted by the pupils. These problems will vary in different localities. The rural school teacher should find out what is being grown on the farm lands, and with the aid of her pupils, endeavor to add to the knowledge concerning these crops. She should keep in touch with departments of agriculture, and current literature along these lines. She should encourage pupils to conduct experiments that they may find out for themselves some things that will improve the farm conditions.

Teachers who are ready to give some time every day to gardening in a rural school should prepare a connected series of lessons in soils, and plants. She will find the following bulletins on agriculture, free to teachers, helpful to her in this work:

Reading Course for Farmers, College of Agriculture, Ithaca, N. Y.

Elementary Exercises in Agriculture, Office of Experiment Station, Washington, D. C.

A Secondary Course in Agronomy, Office of Experiment Station, Washington, D. C.

Applications of Chemistry to Agriculture, Office of Experiment Station, Washington, D. C.

Forestry in the Public Schools, Bureau of Forestry, Washington, D. C.

Syllabus of Agriculture for Secondary Schools, State Department of Education, Albany, N. Y.

For those teachers who would like to do some work in rural school gardening and do not know how to begin, the following lessons will be found helpful. They are simple and involve fundamental principles of agriculture. If but one of these lessons is given during this springtime, it will be worth the while. Do not try to cover too much ground, but if possible, have some one principle of agriculture demonstrated by actual experiment in the vicinity of the schoolhouse.

EXPERIMENTS FOR RURAL SCHOOL-GARDENING

EXPERIMENT I

Composition of Soils

By ETHEL GOWANS

Purpose. To study the composition of some of our farm soils. Soil is composed of particles of rock, and a greater or less amount of humus, air, and soil water. Before soil is a congenial place for roots it must contain a certain amount of heat, and the soil water in which plant food is soluble must be slightly alkaline.

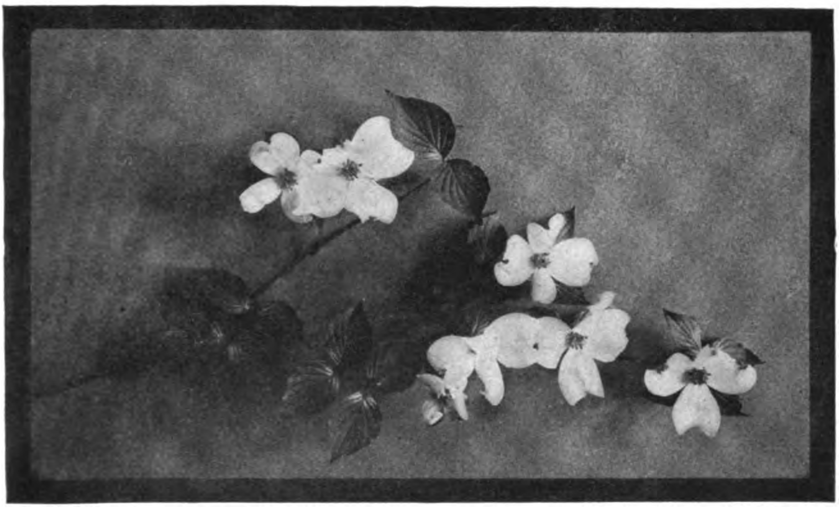

FIG. 74. *Dogwood*

Materials. A cupful of ordinary soil, some humus, three one-quart fruit jars, and water.

Method. Humus is the decaying roots, stems, manure, etc. Leaf mould found in the woods is a good example, and the children should be asked to bring some to school. The sand, silt, and clay can be obtained from the ordinary soil as follows:

Place the cupful of soil in water in one of the jars, and let it soak for a few hours. This will insure the thorough separation of the soil granules.

Fill the jar two-thirds full of water, stir the contents of the jar thoroughly, then let the soil particles settle for one minute.

Drain off the water and suspended soil in it into another jar leaving sand and gravel in the bottom of the first jar. Let the contents of the second jar settle for five minutes, and drain as in the first instance, into the third jar. In the second jar is left silt.

Let the contents of the third jar settle for two or three days, then drain off the water. You have left clay.

Compare the sand, silt, and clay as to origin, color, size of particles, and stickiness. Do you find any more humus in one sample than in another?

Rubbing the soil between your fingers will help you to compare the size of the particles. Bring out the idea that the particles of sand are not only large but also angular; that the particles of humus may be the finest, and give a velvety sensation when rubbed between the fingers. Place some humus soil on a hot stove and notice how it burns. The sand and clay will not burn. The clay particles are fine. This gives the soft, oily feeling when rubbed between the fingers. The particles which are between the clay and sand in size are called silt and also have a soft feeling.

Squeeze some of each of the soils in your hand, then notice which falls apart when you open your hand. The soil which remains in a compact mass when you open your hand is the most sticky. Separate the soil into very sticky (clay); slightly sticky (silt), and not sticky at all (sand).

Which soil ought not to be worked while it is wet? Why? With which soil would it not make any difference?

Name the material in our soils coarser than sand.

Bring out the idea that sand can be detected by its large particles, clay by its stickiness, and humus by the fact that it will burn.

Subject matter. Our farm soils are composed of stones, gravel, sand, silt, clay, and humus. All the particles above 1—25″ (1 mm.) in diameter, are considered either stones or gravel; while sand includes all the particles between 1—25″ to 1—500″ (1 mm. to .05 mm.) in diameter, ranging from coarse sand to very fine sand. Silt includes all particles between 1—500″ and 1—5000″ (.05 mm. to .005 mm.) in size. Clay includes all particles between 1—5000″ to 000. (.005 mm. to .0000 mm.) in diameter. These fine measurements of the sand and clay have been computed by the use of a microscope, and are standard. Humus varies from visible fragments of woody tissue and pieces of twigs to a black powdery material.

The different proportions of these ingredients give us our various farm soils. If sand predominates, we have a sandy soil; if clay, a clay

soil; and if humus, we have a muck. A loam is a mixture of sand, silt, and clay and a little humus. A sandy loam contains more sand than clay, a clay loam more clay than sand, and a gravelly loam is a loam containing a very noticeable amount of gravel. As far as possible have the pupils bring in different samples of the above soils. Discuss with them the way in which soils are adapted to certain crops.

FIG. 75. *Entrance to Ithaca school-garden*

EXPERIMENT II

Capillarity of Soil

By O. S. MORGAN

When you plant seeds, either in the window garden, the outdoor garden, or the field, you firm or pack the soil about the seeds. Almost all seed-planters have some provision for firming the soil about the seeds. Why?

First Lesson.

Purpose. To determine the effect upon the germination of seeds of firming the soil about them.

Materials. Two tin cans, seeds, and soil.

Method. Number the cans 1 and 2. Put prepared soil in both cans. In number 1 leave the soil as loose as possible, and cover the seeds planted in it with loose soil. In number 2 tap the can lightly as you are filling it, then plant the seeds at the same depth as in number 1, but lightly firm the soil over the seeds in number 2. Observe which seeds germinate first.

Second Lesson.

Purpose. To determine the effect of firming soil upon the movement of soil water.

Material. Two tin cans, pie-tin, soil, and water.

Method. Make holes in the bottoms of the tin cans. Number and fill with soil as in experiment one, taking care, however, to get equal amounts of soil in both cans. Firm the surface soil in number 2 so that it is smooth and level; sprinkle dry soil or dust over the surface of both soils. Set the cans of soil in the pie-tin. Fill the tin with water to the depth of a quarter of an inch. Observe in which can the water from below first dampens the surface soil.

Discussion. In both of these experiments you have been observing a phenomenon called capillarity. Capillarity in this case is the passage of water through the minute spaces between soil particles. When the particles of soil are far apart, and there are many large air spaces, the water cannot pass readily by means of capillarity.

In the first experiment the seeds in firmed soil were so closely surrounded by moist soil that capillarity was set up between the seeds and the soil. Thus favorable moisture conditions were established for seed germination. In the second experiment the water from the pie-tin (that represents the water in the subsoil) rose most rapidly in the soil having the soil particles close to each other.

Soil may be so fine and so closely packed that capillarity acts slowly. This is the case with clay soils. In sandy soils capillarity acts quickly. This, however, is starting you on another problem which will be given later.

EXPERIMENT III

How to Grow Good Musk Melons

By ADA E. GEORGIA

The family to which the musk melon belongs does not like to be disturbed in its growth, and seldom thrives again after the check of transplanting. It is such a lover of warmth that outdoor planting must be late, thus making a short season for growth and ripening. But the

writer once had very good success in growing them after the following plan:

First, be certain that the seed is of the best quality. Then, about the first week in April, take a sharp spade and cut several thick turfs of sod—as many as you mean to have hills of melons; cut them about six inches square; if the grassy side of the sod is very firmly matted, slightly loosen the fibers so that the roots may penetrate, but not enough to allow the turf to fall apart. Place the sods bottom-side up in a shallow box of wood or paste-board, and in the earthy side of each plant four or five seeds; if the earth is not thick enough, put on a few handfuls of good mealy soil. Place in a sunny window and keep warm and moist.

When the green cotyledons or seed leaves have freed themselves from the shell, notice which are the thriftiest plants and remove all but the best two. Care for these as you would any house-plant and they will grow, safe from late frosts and also from the striped beetles and other insect enemies. They may safely acquire three or four true leaves and be five or six inches tall before they are planted out of doors.

When the warm, late May-days come, and the apple trees are in full bloom, dig holes about eight inches deep and six feet apart in the sunniest part of the garden, put in the bottom of each a spadeful of old, well-rotted stable manure—that from a cow stable preferred—cover with about two inches of sand or fine soil, and on this place the sod with its growing plant, so gently that it will not know it has been moved. The sod should be level with the ground, and be well "firmed" in place. Leave but one plant in a hill and see that it never suffers from thirst. Keep the weeds pulled and stir the surface of the soil about the hills often until the vines begin to "run."

When each vine has started the growth of about half a dozen little melons, pinch off all other blossoms which form, and also nip the tips of the vines and branches in order that all the plant-food manufactured in the wonderful greenleaf laboratories may be sent, not into new growths, but to thicken and sweeten the golden pulp of the half dozen fruits first chosen.

Big squashes and pumpkins and early cucumbers may be grown in the same way.

EXPERIMENT IV

Alfalfa

By G. F. WARREN

There are four things which often cause failure of alfalfa,—weeds, lack of lime in the soil, lack of inoculation, and lack of fertility. On some farms all four of these points need to be considered; on some they may all be ignored and still be successful; on other farms one or more of them must be taken into account. In order to see whether alfalfa will grow on the school grounds and in order to see how best to grow it, lay out the following plats, each one a rod square. Drive stakes at each corner.

1	3 Inoculation
Lime 2	Lime 4 Inoculation

Sow about eight quarts of lime on plats 2 and 4; that is, four quarts for each square rod, which is equivalent to twenty bushels on an acre. Obtain some soil from a place where alfalfa or sweet clover is growing, and scatter a few quarts of it on plats 3 and 4, being careful not to get any of it on the other plats. Sow a light seeding of oats, or preferably barley. A little over a quart of either one is sufficient. Sow three-fourths of a pound of alfalfa on the area and rake it all in.

After the soil has been sown on the plats, care should be exercised not to rake any of the soil from the plats that receive inoculation to those which did not receive inoculation (the soil from the alfalfa or sweet clover field carries bacteria for inoculation).

No further care will need to be given to the plats until the barley has headed out, when it should be mown for hay, cutting it rather high. The oats or barley should not be allowed to mature, because if allowed to do so they are about as bad for the alfalfa as the weeds which they are designed to displace.

How soon does the barley come up? The alfalfa? In about six weeks begin to examine the roots on the different plats for nodules. During the summer, observe the difference in growth on the four different plats, dig up the young alfalfa plants and look for the nodules on the roots and see whether they occur on the inoculated areas or not, and whether they are more abundant where lime was used.

FIG. 76. *Ithaca public school children receiving instruction in gardening*

The surest way to get alfalfa on a soil that is not especially adapted to it, is to manure the soil well, then cultivate the soil all spring and summer so as to keep the weeds down, then seed the alfalfa alone about the last of July or the first of August, applying lime and inoculation if these are necessary. This work may be carried on at home, if there is no place for it at school, or a farmer living near the school will probably be glad to furnish the land.

EXPERIMENT V

Depth of Planting

BY ETHEL GOWANS

Purpose. To show the importance of depth of planting.

Conditions necessary. Fine, moist garden soil.

Method. Let each pupil plant five hills of beans, one foot apart, and one seed in a hill. Plant the seed in the first hill five inches deep, in the second hill three and one-half inches deep, in the third hill two and one-half inches deep, in the fourth hill one and one-half inches deep, and in the fifth hill one-half inch deep.

Observations. 1. In which hill does the bean plant come up first?

2. Does the plant come up straight through the soil, or in a looped manner?

3. Are all the plants perfect? That is, do they have the first pair of opposite fleshy leaves (cotyledons) with the two smaller thin leaves above (true leaves)?

4. If any plants have lost the two fleshy leaves, compare their growth with the plants which have not lost the fleshy leaves.

5. If any plants fail to come up, what reasons would you give? Dig carefully into the hill and find the seeds; this may help you in answering.

6. Notice the change from day to day in the first pair of leaves.

7. The cotyledons have two uses; what are they?

Subject Matter. The bean seed must be thoroughly soaked with moisture before it will sprout; this is the reason that the seed planted near the surface failed to germinate, and the purpose of packing the moist soil over the seeds.

The food is stored in the cotyledons as oil, starch and protein. In the presence of water these are changed into soluble form by dissolving agents in the seed. In the soluble form they can now be carried to all parts of the plant where they are used as food. The oil, starch, and protein were stored in the seed last summer, and now serve to feed the plant until its leaves are large enough to make its own organic food. These dissolving agents in the seed are analogous to some of the dissolving agents in the digestive juices.

Other Lessons. 1. Sprout twelve bean seeds and then cut the cotyledons from six plants. Compare results. Try the same with squash seeds.

2. Make a list of the other plants that lift their cotyledons above ground. How deep will you plant them? What would be the advantage of planting three or four seeds in a hill?

3. Where is the food stored in the pea and corn seeds?

4. Probably some of the bean plants will have large yellowish-brown spots caused by anthracnose—a common bean disease. Send to Cornell University for Bulletin No. 239. This will describe the disease and give the treatment.

FIG. 77.—*An attractive bit of nature's planting*

EXPERIMENT VI

How to Plant an Apple Tree

BY C. S. WILSON

The apple tree is bought from the nurseryman in the fall or spring. It should be two years' old, and the variety Northern Spy. The tree is planted in the spring as soon as the ground can be worked.

Planting. Dig a round hole large enough to receive the roots of the tree, and deep enough to plant the tree three or four inches deeper than it was in the nursery row. This will cover the bud and crook near the base, When the hole is dug, throw back into the bottom a few shovelfuls of the good surface dirt; then place the tree in the hole. Let one pupil hold the tree straight, while others throw in the soil, at the same time working it between the roots with the fingers. Step on the soil and tramp it down firmly. Fill the hole up level with the surrounding surface.

Pruning. After the tree is set, it should be pruned. Choose three or four side branches, about three feet high, for the main branches. Cut these down to within six or eight inches of the main stem. Cut off all other branches close to the stem, and finally cut back the top of the stem.

The tree will start in the spring and grow during the summer. In August it should be budded to the variety desired. Good eating varieties for New York State are McIntosh Red, Canada Red, Spitzenburg, King, Jonathan and Northern Spy. *Note—Directions for budding will be given next month.*

EXPERIMENT VII

Plant Disease

Treating Potato Tubers to Prevent Scab

BY H. H. WHETZEL

Select a bushel of the scabbiest potatoes that can be found. Divide them into two lots of one-half bushel each. Place one-half bushel into

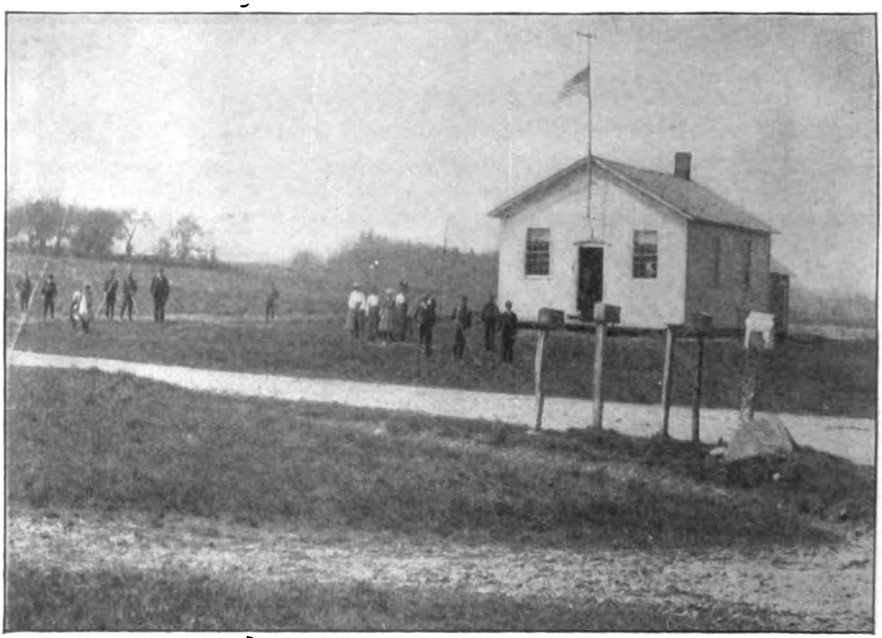

FIG 78. *Beginning to improve the school grounds*

a sack. Into a tub or barrel pour ten gallons of water. To this ten gallons of water add one-third of a pint of formalin, or as it is sometimes called, formaldehyde. This formalin may be purchased at almost any drug store, and will cost about forty cents a pint. Place the sack of potatoes in the tub of formalin solution, spreading them out so that they are entirely covered by the solution. Allow them to soak one and one-

half hours. Remove, cut, and plant. Care should be taken that the tubers so treated are not placed in crates or sacks or other receptacles that have had in them scabby potatoes. It will be best to wash out the basket or crate in which the treated seed is to be put, with the formalin solution left in the tub. Plant the treated tubers in one or more rows by themselves. Then, cut and plant the other half bushel of untreated tubers in rows alongside the treated ones. Mark the

FIG. 79. *A young experimenter*
(Superintendent Kern, Illinois)

treated and untreated rows with stakes. Give all of the potatoes the same sort of care and cultivation throughout the season. When the potatoes are ripe, dig the treated and untreated rows separately. Make a careful count of the scabby potatoes in an equal number of bushels from the treated and untreated rows, taking them just as they come in digging. Make a count also of all the potatoes in the bushels taken, and calculate the percentage of diseased potatoes in the

treated and in the untreated rows. A careful record should be kept of the time required to treat the seed and the cost of materials used. After the potatoes are all dug and above accounts carefully made, the student should be required to calculate, at the current price per bushel, the total increase in value due to seed treatment.

MAKING A GARDEN

By C. E. Hunn

1. *Preparation of land.* If the location of the garden may be secured in the fall, much of the preliminary work could be done before freezing weather, having all leveling done, rough material removed, and the ground ploughed or spaded. Fall plowing is to be recommended from the fact that the winter freezing has a beneficial action on the soil, causing it to crumble and separate into fine particles. It is also possible to work fall-plowed land earlier in the spring than flat lying land. If spring plowing must be done, it is best to start as early as the ground is fit to work. A good coating of barnyard manure spread evenly over the ground before plowing is always beneficial. Plow to the depth of from four to six inches and harrow the soil fine with a spring-tooth harrow, after which the small stones and rubbish may be raked off with the hand rake, and the ground leveled for sowing seeds.

2. *Sowing the seeds.* In sowing the seed it is much better to sow in rows than to sow broadcast. The seedling may be more easily identified, thinning and weeding may be quickly done, and the soil between the rows may be hoed without injury to the seedling plants.

In planting a garden it is best if possible to have the rows extend north and south, each row having its share of sunlight. If the rows are east and west, and one or more rows contain tall plants there is danger of shading the rows in the rear.

3. *Watering the garden.* If it is necessary to water the growing plants, it should be done late in the afternoon, if possible. If watered in the morning, the sun causes very rapid evaporation, leaving the soil dry, and in heavy soils causing it to bake. Thorough cultivation of the soil or a mulch of either grass or straw will hold the moisture in the soil and lessen the need of water.

4. *Soils.* It is not often that a heavy clay soil will be found. If no other soil is obtainable, drainage, sand, muck, grass, or coal ashes will be beneficial. Clay soil should never be worked when wet. Gravelly loam, sandy loam or even clay loam are easily worked, and are the soils generally found to give good results. See Lesson on soils, page 121.

5. *Starting plants.* The seeds of all but the ranker growing plants may be started in the house through March or April, using shallow boxes filled with light soil. A little care is needed not to sow the seeds too early, for if the window conditions are such that the plants grow spindling, they transplant with difficulty. Six weeks before the time to plant out of doors is early enough to sow the seeds in boxes, and it is then often necessary to transplant into other boxes before the ground is fit to receive the seedlings. For the first year it would be well to have the children grow some one thing in-doors, in order to give them a lesson in transplanting. Tomato plants would be good for the first lesson. If flowers are desired, pansies might be started in boxes.

List of Garden Vegetables, seed of which may be sown as soon as the ground is fit to work in the spring.

Variety	Time of Sowing	Depth of Sowing	Soil Best
Asparagus	April	1 inch	Light Loam
Beets	"	2 "	"
Carrots	"	1 "	"
Chicory	"	1 "	"
Cress	"	½ "	"
Kohlrabi	"	1 "	"
Endive	"	1 "	"
Kale	"	1 "	"
Leek	"	1 "	"
Lettuce	"	1 "	"
Mustard	"	1 "	"

Variety	Time of Sowing	Depth of Sowing	Soil Best
Onion	April	1 inch	Light Loam
Parsnips	"	1 "	"
Parsley	"	½ "	"
Peas	"	2½ "	"
Radish	"	1 "	"
Rutabaga	"	1 "	"
Salsify	"	1 "	"
Sea Kale	"	1 "	"
Spinach	"	1 "	"
Turnip	"	1 "	"

List of Garden Vegetables, seed of which should not be sown until the ground is warm and all danger of frost is over.

Variety	Time of Sowing	Depth of Sowing	Soil Best
Beans	May 10	2 inch	Light Loam
Corn	" 10	2 "	"
Okra	" 20	1 "	"
Pumpkin	" 10	2 "	"
Squash	" 10	2 "	"

Annual Flowers: Seed to be sown after danger of frost is over. The best results are obtained if the plants are started in the house in April, and set out after the *tenth of May*.

Variety	Time of Sowing	Depth of Sowing	Soil Best
Antirrhinum	May 5 or after	1 inch	Light Loam
Aster	" "	1 "	"
Cockscomb	" "	½ "	"
Cosmos	" "	1 "	"
Dahlia	" "	1 "	"
Lantana	" "	1 "	"
Mignonette	" "	1 "	"
Myosotis	" "	1 "	"
Ricinus	" "	2 "	"
Salvia	" "	1 "	"
Schizanthus,	" "	1 "	"
Stocks	" "	1 "	"

Annual Flowers: Seeds to be sown early.

Variety	Time of Sowing	Depth of Sowing	Soil Best
Adonis	Apr. or early May	1 inch	Light Loam
Ageratum	"	½ "	"
Alyssum	"	½ "	"

Variety	Time of Sowing	Depth of Sowing		Soil Best
Amaranth	Apr. or early May	1	inch	light Loam
Brachycome	"	½	"	"
Browallia	"	1	"	"
Calandula	"	1½	"	"
Calliopsis	"	1	"	"
Candytuft	"	½	"	"
Carnation	"	1	"	"
Centaurea	"	1	"	"
Chrysanthemum (annual)	"	1	"	"
Clarkia	"	1	"	"
Dianthus	"	1	"	"
Eschscholzia	"	½	"	"
Euphorbia	"	1	"	"
Gaillardia	"	1	"	"
Godetia	"	1	"	"
Gypsophila	"	1	"	"
Helichrysum	"	1	"	"
Larkspur	"	1	"	"
Lobelia	"	½	"	"
Marigold	"	1	"	"
Mignonette	"	½	"	"
Nasturtium	"	2	"	"
Nicotiana	"	½	"	"
Nigella	"	1	"	"
Petunia	"	½	"	"
Phlox D	"	1	"	"
Poppy	"	½	"	"
Portulaca	"	½	"	"
Pyrethrum	"	1	"	"
Salpiglossis	"	1	"	"
Scabiosa	"	½	"	"
Sweet Pea	"	4	"	"
Verbena	"	1	"	"
Zinnia	"	1	"	"

List of Popular Perennials: Plants to be grown the previous summer.

Variety	Time of Planting	Depth of Planting		Soil Best
Abutilon	May	3	inch	Any well-enriched, well-drained soil. Light loam preferable.
Aquilegia (Columbine),	April	3	"	
Bellis perennis	"	2	"	
Campanula	"	3	"	
Canna	May	4	"	
Delphinium	April	3	"	
Digitalis	"	4	"	
Gaillardia (hardy)	May	3	"	
Hollyhock	April	4	"	
Poppy (hardy)	"	3	"	
Rudbeckia	May	4	"	
Sunflower (hardy)	"	3	"	
Sweet William	"	3	"	
All hardy pinks	"	3	"	

List of Shrubs for Garden Borders:

Almond (flowering), Cornus, in variety, Elder, Forsythia, Hydrangea, Honeysuckle (bush), Japan Quince, Kerria, Lilac in variety, Mahonia, Privet, Roses in variety, Snowball in variety, Spirea in variety, Sumac, Weigelia, Witch Hazel, Evergreens, Dwarf Thuja, Retinispora, Junipers, Norway Spruce, Dwarf Pine.

List of early vegetables that should be started inside in April, and the plants set out as soon as ground is fit. Variety—Brussels sprouts, Cabbage, Cauliflower, Celery, Celeriac.

List of late vegetables, the seed of which should be started in April, and plants set out after the tenth of May. Cucumber, Egg Plant, Melon, Pepper, Tomato.

CORNELL
Rural School Leaflet
FOR BOYS AND GIRLS

Published monthly by the New York State College of Agriculture at Cornell University, from September to May and entered as second-class matter September 30, 1907, at the Post Office at Ithaca, New York, under the Act of Congress of July 16, 1894. L. H. Bailey Director

ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. I. ITHACA, N. Y., APRIL, 1908. No. 8

FARM BOYS' CLUB OF NEW YORK STATE

MY DEAR BOYS:

By this time you have carefully thought about having those "little farms." You have spoken to your parents about it. You now want to know what to do first.

A Boys' Club.

Ask your teacher to call a meeting at the schoolhouse of all the boys in the district, whether in school or not, between the ages of ten and eighteen. All boys should know how to organize themselves, for in this way is learned that great lesson of co-operation so vital today in rural

districts. Your fathers have to manage school meetings, milk dealers' associations, co-operative creameries, town meetings, granges, and the like. We need to prepare ourselves for these events just as much as to study geography or history.

Let one of the older boys, at the suggestion of the teacher, call the meeting to order. Then let some boy rise and say, "Mr. Chairman, I nominate John Dickson (for example) for President." Another boy rises and says, "Mr. Chairman, I second the nomination." Probably there will be no other nominations. Then let some one rise to say, "Mr. Chairman, if there are no other nominations, I move that John Dickson be declared elected President of this club." Some one says, "I second the motion." Then the boy who is acting as Chairman says, "It has been moved and seconded that John Dickson be declared elected as President of this club. Are there any remarks?" Hearing none, he says, "All those in favor say, 'Yes.'" He counts the vote. "All those opposed say, 'No.'" Again the vote is counted, and the Chairman declares that John is elected, if he receives more votes for than against. Then John takes the place of the Chairman and conducts the meeting.

Ask your teacher to help you to select the rest of the officers. The older boys can write out a constitution for the club, stating what its purpose is, how often it is to meet, and how long the officers are to serve. A motto should be selected, colors adopted, and a distinctive button chosen.

The name of every boy in the club should be sent to the College at once. All names in the same club should be sent in together. No names will be accepted after the 15th of May.

The work of organizing the clubs will be carried on by counties. Each district school will be a part of the larger county school organization of Farm Boys' Clubs for your particular county. In this way you will have a better chance to reach your county fair association for the purpose of making an exhibit.

A member of the club in any county may select any plat of ground not to exceed one acre in size nor less than one-eighth of an acre. All work of preparing the soil as well as the planting or sowing must be done by the boy.

Later on, rules will be published in regard to selecting some disinterested person to measure the ground in the fall and the crops when gathered. Suggestions will also be made as to getting the crop on the market or at the fair, in order that each boy receive as much cash returns as possible.

Where there is sufficient local co-operation, cash prizes of Fifty

Dollars will probably be offered in each county in the following way: For the best individual exhibit at a school fair, First Prize, Ten Dollars; Second Prize, Five Dollars; Third Prize, Three Dollars; Fourth Prize, Two Dollars; the next five prizes One Dollar each. For the best club exhibit at the county fair, Ten Dollars, First Prize; Five Dollars, Second Prize; the remaining Ten Dollars for the best and second best individual exhibits at the county fair. From the exhibits at school and county fair both individually and as organizations, will be selected the best to be sent to the State Fair, where all the different counties with their clubs will be represented and compete for the big prizes to be offered later.

Each boy or club should decide just what particular crop is to be grown as for instance, corn, beans, peas, potatoes, oats, wheat, rye, roots, and other farm crops; selected tomatoes, celery, radish, melon, and other vegetables. Be sure to get the very best strains of the crop selected. Flowers will greatly improve your garden. Use your own taste in this.

For those interested in raising poultry a special cash prize will be offered for the best exhibit at the school, county, and State fairs. Details may be had on application. Bulletins descriptive of these different crops and competitions may be had on application.

When you have decided on the particular crop that you would like to grow, send for seeds at once to the New York State College of Agriculture, enclosing five cents in stamps to pay for the postage, and to apply what is left on the price of the seeds. Full directions as to how to plant the seeds will be sent with each package. By getting seeds in this way you will get some of the purest strains of corn, potatoes, wheat, and the other crops desired, with which you ought to be able to produce more to the acre than you could do with ordinary seed. Remember that you are to become good farmers. To do so you must use the very best kind of seed available. Perhaps you will be able to increase the amount per acre of some of the different crops grown in your neighborhood.

You may ask what there is to do after you have put your seed into the ground, while waiting for cultivation. Suppose that you plan some meetings once in a while at one another's houses, and on such an occasion the father of one of the boys might give his experience with some particular crop with which he has had success. If your teacher would arrange to have two or three school clubs in your vicinity meet, we would arrange to have some one from the College meet with you and help you with some of your problems.

You might begin to get together selected books for a library for your club. We will give you a list of some desirable books and bulletins which treat of the different crops or competitions in which you are interested.

I think it would be a good deal of fun to have an excursion some day to visit the farm of one of the neighbors where the work is carried on in a business-like, practical way. You may have heard of some man who has been successful in come line of animal breeding. You might take a trip to see him. If you are near an agricultural school, plan to visit that sometime, by all means. If you are not too far away from the College of Agriculture, we would like to have you plan this very spring or next fall to visit it. Then we would have a chance to show you just what other boys are doing.

You could have debates in your club upon which is the best kind of farming, or which kind of animal breeding you would like to take up.

Then, remember that we are to plan a field day during the spring or summer when we can have a picnic with some games as we talked about last month.

Which school will organize the first club? Don't let the other fellow get ahead of you. Write to me, *now*, before you forget it. The supply of seed will soon be exhausted. Someone will be told, "Too late, Jim, this time."

Yours for the Boys' Club,

CHAS. H. TUCK.

NOTES

Next month we shall discuss the Girls' Club.

Every boy and girl should write at least three letters to Uncie John before the close of the year. To all who do we shall send a picture. In your leters tell us something that you have learned from the Leaflets this year.

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ALICE G. McCLOSKEY, Editor

Professors G. F. WARREN and CHARLES H. TUCK, Advisers

Vol. I. ITHACA, N. Y., MAY, 1908. No. 9

FARM GIRLS' CLUB

TO every girl in New York State we extend an invitation to become a member of the Farm Girls' Club. Doubtless you have read in the April Leaflet that the farm boys are busy organizing and planning work and play for the coming year. We want to have the farm girls do some work and have good times, too.

If you have not already done so, talk this matter over with your teacher. Ask her to call in all the girls in the neighborhood whether they are in school or not. We want every girl in the district between the ages of twelve and eighteen years of age to be members of this club.

The boys are going to do some work out in the fields. This is going to help them to be the most intelligent farmers in the community. They are starting young and that is the way to prepare for a good life work.

Now what are the girls going to do? Do you know that it is a great privilege to be a girl? I wonder if girls know how important they are in the lives of every one about them? How much there is for them to do, even for little girls, and what a joy there can be in the doing? While the boys are afield, learning to be intelligent farmers, I want the girls to be preparing themselves to make the home in which they live the very brightest, most cheerful, and most attractive in their community. This will be the purpose of the Girls' Club.

Ask your teacher to organize your club in any way that she thinks best, either formally or informally, and send your names to us. It might be well for you to have officers through whom you can carry on your business affairs for there will be letters to send to the University, questions to be asked, and the like. You will not want to bother your teacher to carry on this correspondence.

Beginning with the September issue of the Cornell Rural School Leaflet, suggestions will be given each month for the Girls' Club. There will be play as well as work. We shall consider the following:

I. Outdoors:
1. Beautifying the home grounds; the school grounds.
2. Gardening.
3. The common things near home; the trees, birds, wayside blossoms, animal life, and the like.
4. Helpfulness about the farm home.
5. Games and how to play them.

Every girl ought to be a good home-maker. Love of the out-of-doors will help in this. If she would keep her mind wholesome and happy, she must spend some part of every day, rain or shine, in the great out-of-doors. The fresh air will help to give her red cheeks, bright eyes, and cheerful smiles, and these things are important to good home-makers.

II. Indoors:
1. Cooking.
2. Sewing.
3. Helpfulness in the farm home.
4. Care of your own room.
5. Neatness.
6. Some good books for girls to read.
7. Something about pictures.
8. Games for winter.
9. Social life.

Prizes will be given this year for work done in the Girls' Club. From the following list of subjects, select one that interests you most, do some work along the line suggested, and send us a full description of what you have done. If your composition prove to be the best on this subject we shall send you one dollar. You should tell the teacher in your school district what subject you have chosen, and ask her to indorse the written description that you send us. She will be willing, I am sure, to take an interest in what you do, and perhaps make suggestions that will be helpful to you.

SUBJECTS FOR FARM GIRLS TO CONSIDER THIS SUMMER

1. Improvement of school grounds.
2. Improvement of home grounds.
3. Gardening.
4. Helpfulness in the home. This should be a description of some piece of work that you have done or that you do daily in the farm home to help your mother.

Out in the Country.

5. Helpfulness out of doors. Any piece of work that you have done to help in the work of the farm. Gathering fruit and vegetables; collecting the eggs; preparing produce for market; feeding the poultry; caring for young poultry, and the like.
6. Care of a pet among the farm animals.
7. Learning to milk.
8. Preparing an exhibition for the county fair.
9. Prizes won at a county fair.
10. Knowledge of some natural object; trees, birds, wayside plants, animal life of field and forest.

11. The games that girls can play in the country.
12. The books you like best and why you like them.

Your composition must show that you are familiar with your subject. Do a piece of work, read a book, or play a game; then tell us about it. Such a composition will be considered for a prize. Every one try. The competition will close Oct. 15, 1908.

ALICE G. MCCLOSKEY.

EXHIBITION WORK

At a meeting of the New York State Science Teachers' Association and the New York State Teachers' Association to be held in Syracuse in December, 1908, there will be a Cornell Exhibit of public school work in nature-study and agriculture. We want every boy and girl to help us to make this exhibit worth the while.

Anything that has to do with the study of nature will be acceptable for the exhibit. This will, of course, include agricultural work done by girls and boys, since agriculture is nature-study. We shall be glad to receive compositions, drawings, and herbariums. Collections of the eggs and feathers of poultry, as suggested in the lessons in the Cornell Rural School Leaflet will be satisfactory. *We do not want collections of eggs and feathers of wild birds.*

In the manual training department of some schools, pupils have learned to make things that have helped them in their outdoor study. Some classes have made bird houses, tools, baskets, instruments used for measuring horses, cages for studying insect life, attractive markers to be placed beside each plat in the school garden, butter-prints designed and made by the children, and many other things. We should like to borrow some of this work for the exhibit. What can your school send us?

During the summer you might make collections of different kinds of soils. Prepare compositions to send with the collections, making statements as to where the soils were found, and any knowledge you have concerning them.

Some boy may care to make a study of commercial fertilizers and send small samples of each in bottles or boxes with his composition. A collection of weeds of field, wayside, or garden would be interesting. Some boys and girls might like to make collections of grasses or grains.

Keep all the exhibits until we tell you when to send them to us, and where to send them.

Note.—In the April Leaflet directions were given for summer work for the Boys' Club. Any boy who has not received a copy should apply for one immediately. There is a letter in the Teachers' Leaflet this month for the members of the Farm Boys' Club. Ask your teacher to read it to you. All communications in regard to the Boys' Club should be addressed to Prof. C. H. Tuck, Ithaca, N. Y.

CORNELL
Rural School Leaflet
SUPPLEMENT FOR THE TEACHER

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VOL. I. ITHACA, N. Y., MAY 1908. No. 9.

MORE ABOUT GARDENS
I. THE GARDEN MULCH

BY C. E. HUNN

On many school gardens as well as on many home gardens, the lack of a good supply of water often results in a partial failure of the crop or means hard work in carrying water. This lack of water may be overcome by the use of some kind of mulch. The mulch serves several purposes: conserving moisture in the soil by preventing evaporation; keeping the surface of the soil loose; protecting the plant roots from injury by frost; and to a certain extent with some materials adding plant food to the soil. The first two considerations are perhaps the most important in the school garden, and even where water may be used in quantity, it is often better to mulch the ground around the plants than to use water freely.

FIG. 80—*Thinning the plants*

On heavy soils constant watering will cause the soil to become sodden and sour, when by using two or three inches of mulch the soil will

remain loose and sweet. Mulch is also valuable on light, sandy soil where evaporation is rapid. Plants demand moisture around the roots, but do not thrive with their roots standing in water; and where a mulch is used there is a constant supply of moisture rising through the soil which will be held near the surface by the mulch.

The material that can be used as a mulch may be anything supplying shade, and lying close to the ground: short grass, straw, hay, coarse manure, leaves, and old boards. Stirring the surface of the soil with a hoe or rake will produce a "dust mulch" that will be of benefit; in fact, in large gardens and with farm crops the cultivation of the surface soil is the only method of furnishing a mulch that can be used.

II. THINNING AND TRANSPLANTING

BY C. E. HUNN

To have a good garden each plant should have room for its fullest development, and since most of the seeds of garden flowers and vegetables are small, it is almost impossible to sow the seeds sparsely enough so that each plant will thrive and grow to perfection. Since this is the case, the plants must be "thinned," and either thrown away or transplanted to some other part of the garden. If the thinning is done in cool, cloudy weather, the seedlings may be transplanted with great ease, but if done in dry, sunny weather, the seedlings must be shaded after being set out. It is best to thin the plants when they are small, before they have become crowded, but if one wishes to save them for transplanting, they may be left until large enough to handle. The following will be found helpful to young gardeners in thinning and transplanting:

I. *Flowering plants that should be four inches apart*: Alyssum, ageratum, balsam, candytuft, lobelia, pansy, poppy, portulaca.

II. *Flowering plants that should be from six to eight inches apart:* Amaranthus, browallia, carnations, centaurea, dianthus, eschscholtzia, gaillardia, mignonette, myosotis, phlox D.

III. *Flowering plants that should be twelve inches apart:* Aquilegia, asters, campanula, calliopsis, colosia, helichrysum, heliotrope, larkspur, marigold, nasturtium, "drop", nigella, petunia, salpiglossis, scabiosa, verbena, zinnia, sweet william.

IV. *Flowering plants that should be from eighteen to twenty-four inches apart:* Canna, chrysanthemum (annual), cosmos, dahlia, delphinium, digitalis, gypsophila, nicotiana, phlox (hardy), salvia, rudbeckia, schizanthus, tritoma.

V. *Vegetables that should be six inches apart:* Beets, celery, lettuce, parsnip, parsley, spinach, salsify, turnip.

VI. *Vegetables that should be twelve inches apart:* Beans, cabbage, cauliflower, egg plant, endive, kohl rabi, pepper.

VII. *Vegetables that may be sown thickly:* Carrots, leek, onion, peas, radish.

VIII. *Vegetables that should be from three to four feet apart each way:* Beans (pole), corn, cucumber, kale, melons, squash.

III. THE APPLE TREE IN THE SCHOOLYARD

"What plant we in this apple tree?
Fruits that shall swell in sunny June,
And redden in the August noon,
And drop, when gentle airs come by,
That fan the blue September sky,
While children come, with cries of glee,
And seek them where the fragrant grass,
Betrays their bed to those who pass."
At the foot of the apple tree."
William Cullen Bryant

In the April issue of the Leaflet we asked the boys and girls to plant an apple tree in the schoolyard or in their home yard,—one which might be budded to any variety that they should choose later in the year. I am wondering how many apple trees were planted in or about rural schoolyards by children? If a tree was not planted, perhaps the children can be encouraged to select an apple tree near the schoolhouse, and a committee appointed to bud this tree to some desired variety next August. If the teacher should be away at this time, perhaps some farmer in the neighborhood would meet with the children and help them in budding the tree. Please let us know if you have made any effort to have the children do this piece of work in connection with their lessons in agriculture.

A LESSON IN BUDDING

BY C. S. WILSON

Budding is such an interesting and important farm operation that every boy and girl should know how to do it. It is so simple, too, that one can learn it in a few minutes. Think of changing the little apple trees in the orchard, or those that come up in the fence row to any variety of apple you wish! And this is exactly what budding is for. It is to change the variety of a fruit, and this change can be made on branches as small as a lead pencil or as large as the thumb.

The nurseryman buds the little trees in the nursery row about two or three inches above the surface of the ground, inserting a single bud in each tree. The fruit grower top buds the trees he has set in the orchard the spring before, inserting two or three buds in the main stem of each tree about three feet from the ground. This is what you will do if you have planted a Northern Spy tree in the spring.

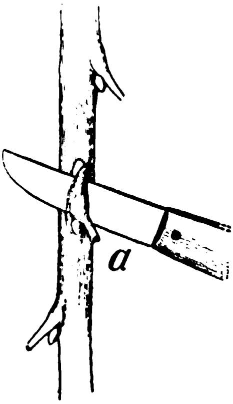


FIG. 81

Plan to bud the tree in August. At this time the bark peels readily. It would peel in the spring also, but then the flow of sap is so great that the little bud would be drowned or forced out of the bark. Later in the fall than August, the bark becomes so dry that it will not peel.

To Prepare the Tree or Stock. Choose the place for the bud. Make a horizontal cut across the stem just through the bark. This cut should be made with a rolling motion of the knife, and should be crescent-shaped. Then, beginning in the middle of this crescent-shaped cut, draw the knife straight down making a vertical cut. Fig. 82. To loosen the bark, twist the knife sidewise before drawing it out. The stock is now ready for the bud.

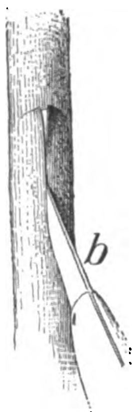


FIG. 82

The "Bud Stick." Take the buds from bearing trees of the variety you wish. From the ends of the branches cut twigs which have grown this spring. These are called "bud sticks." The leaves are still on them. At the base of each leaf and between the leaf and the branch, you will find a little bud. This is the bud you wish to insert into the tree, which has been prepared as above.

To Cut the Bud. Cut the leaves off the bud stick about a quarter of an inch above the bud, thus leaving the base of the leaf stalk as a handle for the bud. Also cut off the upper portion of the bud stick three or four buds from the end. These end buds are soft and immature, and should not be used. Cut each bud as you use it. Beginning with a sharp knife below the bud, cut upwards just through the bark beneath the bud and above it about half an inch. Be sure to cut through the bark, but be careful not to get much wood beneath the bud. The illustration (Fig. 81) shows how to cut the leaves from the bud stick, and also how to cut the bud.

Inserting the Bud. Push the bud down into the incision made in the stock, using the leaf stalk as a handle. Be sure that the entire bud is shoved into the incision. If a portion of the bark should project above, cut it off. Fig. 83.

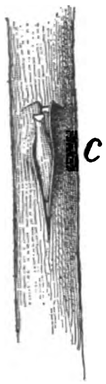


FIG. 83

Tying. The bud is now ready for tying. Raffia is the best material to tie with, but if that is not available, use ordinary string. Wrap the wound entirely except where the bud is. Begin below the bud to wind the raffia. Wrap it carefully and snugly up to the bud, around the sides and above the bud beyond the top of the wound. Then tie securely. Fig. 84.

FIG. 84

Later Treatment. Leave the raffia or string about two or three weeks when the bud will have "stuck." Then remove the raffia. It is the common practice to draw a sharp knife over the strings on the side opposite the bud, completely severing them, and allowing them to fall off as they will. The bud will remain dormant during the winter, and will begin to grow in the spring. After the buds have grown one year choose the strongest branch, and cut off all the others. From this branch allow the main branches of the tree to grow.

And when, above this apple-tree,
The winter stars are quivering bright,
And winds go howling through the night,
Girls, whose young eyes o'erflow with mirth,
Shall peel its fruit by cottage-hearth,
And guests in prouder homes shall see,
Heaped with the grape of Cintra's vine
And golden orange of the line,
The fruit of the apple-tree.

* * * * *

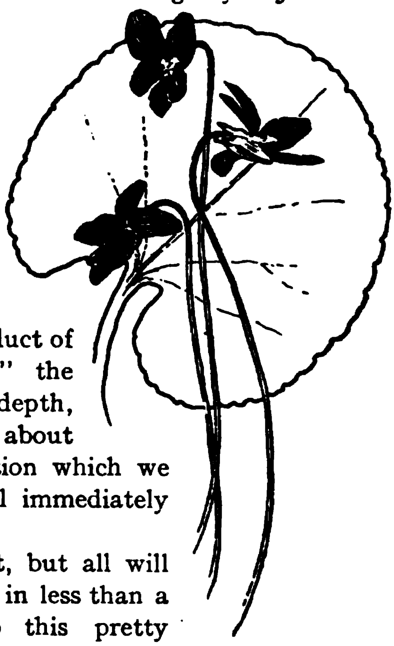
The fruitage of this apple-tree
Winds and our flag of stripe and star
Shall bear to coasts that lie afar,
Where men shall wonder at the view,
And ask in what fair groves they grew;
And sojourners beyond the sea
Shall think of childhood's careless day,
And long, long hours of summer play,
In the shade of the apple-tree

WILLIAM CULLEN BRYANT
From Songs of Nature
McClure, Phillips & Co

IV. A SALAD FESTIVAL

By John W. Spencer

The early closing of school renders it difficult to take continuous good care of many school gardens, but a salad garden may be sown, grown, and harvested between the first of April and the closing day in June.



If there is a place on the school grounds which the children will hold sacred from their games, let it be devoted to three beds, each about a yard long and a foot wide, and planted respectively to peppergrass, radishes, and lettuce. The preparation of these beds: the spading and making fine the soil; the addition and mixing in of fertilizer, whether of the commercial sort or the well-rotted product of a stable; the straight "marking off;" the planting of the seeds at the proper depth, and the "firming" of the soil snugly about them, may all be made a demonstration which we hope every "apprentice gardener" will immediately put into practice at home.

The peppergrass will germinate first, but all will be above ground in about a week and in less than a month will need thinning out. Do this pretty thoroughly, for no plant grows well when crowded. These "thinnings" may be used to make more appetizing the bread and butter of the school lunches, but for the great day there should be special preparation.

A day or two preceding some Friday afternoon, when the peppergrass is well-grown, green, crisp and crinkly, when the radishes are plump and full of juicy pungency, when the lettuce is forming little ruffled leaves a little larger than a pussy-cat's ears, let the parents of the gardeners receive a written invitation to a salad festival.

Some of the young hosts and hostesses will be pleased to furnish a few hard-boiled eggs, others a loaf or two of fresh bread, and some may be skillful in making mayonnaise or cream salad dressing. Hard-boiled eggs, peppergrass, radishes, and lettuce chopped together and spread with salad dressing makes a most delicious stuffing for a sandwich, but I dare say that my nieces know better how to combine these ingredients than their uncle can tell them.

With songs and recitations to precede the refreshments, here is an entertainment for teachers, pupils, and parents to thoroughly enjoy, especially when it has been entirely the work of the pupils, and they are feeling to the full extent the pride and delight of ownership and accomplishment.

V. LIFE IN THE GARDEN

By Alice G. McCloskey

From midsummer until late autumn the study of life in a garden affords abundant material for nature-study. It is a place in which the children may carry on their observations without disturbing anyone. It is their own laboratory. Here they may collect and investigate on their own ground.

One fall day I spent an afternoon with forty public school children in one of our gardens. It was in early September. The air was cool, the sky deep blue, the garden glorious with brilliant color.

The children and I sat in the assembly arbor, and discussed the garden as it lay before us. Many of the individual beds had been neglected, the children having been away from home during the vacation, yet the owners were interested in the things that had survived the competition of weeds and insects.

Of the forty children present, I found but two who could name the flowers then in blossom in the borders on either side of the entrance walk. These flowers were dwarf nasturtiums, bachelor's buttons, marigolds, zinnias, larkspur, and sunflowers. It seemed to me the garden was quite worth the while, if for no other reason than that these forty children should become interested in these flowers, many of which were new to them. I decided to have them spend the afternoon in making notes on the flowers that were in blossom, giving date, and facts of interest. Any child was privileged to ask the names of plants with which he was not familiar. Besides the flowers in the borders, there were many in blossom in other parts of the garden: phlox, mignonette, alyssum, forget-me-nots, pansies, verbenas, dusty miller, maid-in-the-mist, petunias, candytuft, cock's comb, and other plants. The children were asked to spend an hour in looking at the blossoms, naming them, making notes as to height, size of blossom, and other points that occurred to them.

As I watched these children at their work, I felt repaid for any effort that had been made in developing the garden. They frequently asked the names of certain plants, and instead of going with them to see each one, I asked them to describe it. Sometimes they were obliged to return to the plat or border to get a more accurate description by which I could recognize it. This was a valuable lesson in accuracy of observation.

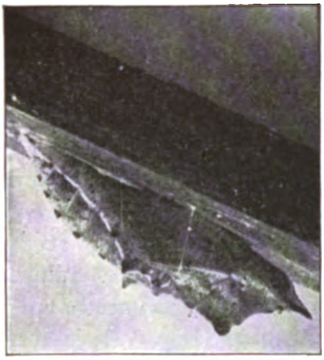


FIG. 85—*Chrysalis of cabbage butterfly*

During the afternoon many interesting observations were made along the lines of animal life. Two stages of the Monarch butterfly were found, the larva and the adult. The children captured an adult, and without injuring it in any way, I was able to show them its long tongue, and the way in which it gets nectar from the flowers. They also found a Viceroy butterfly, and we compared the Monarch and the Viceroy, so much alike that close observation on the part of the children was needed to determine the difference between them. We kept on our school grounds a glass globe with mosquito netting over it, under which the insects were placed for observation. Young children get quite as much benefit from this method of insect study as from mounted specimens.

Our young gardeners were much interested in the toads that were hopping about. They learned that toads would not give them warts, and that they make very interesting pets. When the value of these little creatures in helping to destroy injurious insects was discovered, the boys and girls made effort to keep them on their own garden plats.

A little "bat" was found asleep upside-down in a sunflower. I told the children that bats earn the privilege of sleeping in the daytime, since, as Professor Hodge expresses it, "They are little night police," and

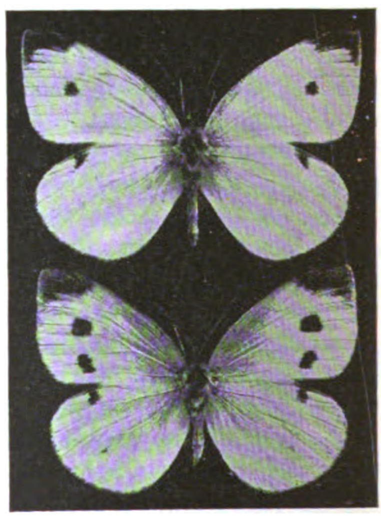


FIG. 86—*Cabbage butterfly. Upper figure male; lower figure female.*

destroy many injurious insects in the gardens at night. This was a new fact for many of the children, and the little bat became an object of interest.

FIG. 87—*Chryalis of the tomato worm*

Let us encourage the children to make a special study this summer of one or two forms of life in the garden. They will learn facts about many other forms but it is well to have them learn as fully as possible the life history of one or two. I would suggest for the coming season, the life history of the cabbage butterfly and the tomato worm. Following are some suggestions that may be helpful:

THE CABBAGE BUTTERFLY

The cabbage butterfly can be found in the garden in four stages of its development: egg, larva or caterpillar, chrysalis, and butterfly.

The eggs are yellowish-green in color, somewhat pear-shaped, and about the size of a large mustard seed. They are scattered irregularly over the leaves of the cabbage and some other vegetables, being fastened to the under side of the leaves.

The caterpillars feed principally on cabbage leaves. They are green with a narrow, greenish, lemon-yellow band on the back. Place a caterpillar in a glass covered with mosquito netting and feed it fresh cabbage leaves. It will probably change to a chrysalis in the glass, and later the butterfly will come from the chrysalis.

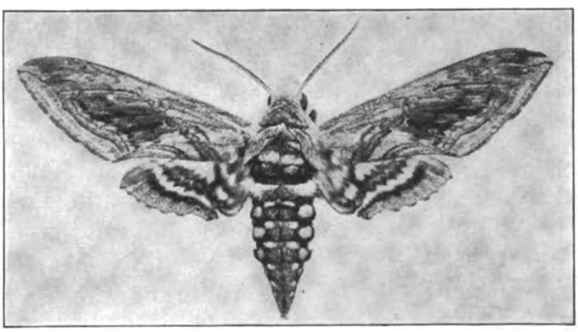


FIG. 88—*Hawk moth. This moth develops from the tomato worm*

The wings of the butterfly are a dull white above, occasionally tinged with yellow, especially in the female; below, the apex of the fore wings and the surface of the hind wings are pale lemon-yellow. In the female there are two spots on the outer part of the fore-wing besides the black tip, in the male one. Fig. 86.

THE CATERPILLAR ON THE TOMATO PLANTS.

The tomato worm feeds on the leaves of the tomato, tobacco, and potato. It is a large caterpillar, usually green in color. These caterpillars do not excrete poison from the horn near the end of the body as has been stated.

The pupa is often found underground and resembles a jug with a handle. Boys and girls may sometimes dig up the pupae from around tomato plants.

The moth that comes from the pupa is large, measuring four or five inches. It has many shades of ashgray, marked with black or very dark-gray.

Nature has some very interesting ways of controlling insect life. The tomato worm is infested by insects that feed in its body, and when they change to the pupa state, you can see their cocoons on the back of the worm. Some children think these cocoons are eggs. The tomato worm infested by these insects does not live to develop into a moth.

DAIRYING

By R. A. PEARSON

THE lesson on testing milk by the Babcock method, to find how much fat it contains has proved to be well adapted for grade schools. The College agreed to loan testing outfits to a limited number of schools, and already twenty-four schools have been supplied. These are located in different counties of the State. Fourteen other schools have applied, and testing outfits will be sent to them as soon as they are returned from the persons now using them.

The test has value for school work because of the useful instruction which it provides. This includes simple problems in arithmetic and valuable training in accuracy. Here we have a method for emphasizing the importance of accuracy which must make an impression upon the young mind. Let the child take a sample of milk from a pint or quart jar, then another sample for a duplicate test, and unless these are measured accurately and other conditions accurately complied with, it will be found that the tests do not agree.

Knowledge of the test is valuable also because it is now in general use where good dairy work is carried on. It needs to be more widely adopted and this will be brought about more readily when it is stripped of its mystery, as may be done in the schools.

Care is also taught by means of the Babcock test. The acid used is very strong. and will cause serious damage if it comes in contact with almost any substance, and painful injury if it comes in contact with any part of the person unless immediately washed off. The one great precaution always to be kept in mind is that the acid must be carefully handled, and persons should not unnecessarily expose themselves to harm from the acid either when it is being measured or poured, or when the bottles are whirling and one might by chance break.

Those children who live in the vicinity of creameries or other places where milk is bought on the basis of its fat test will find it interesting to visit these places and see the tests made on a large scale. The principle is the same, but when many samples are to be tested, machines run by steam power are used.

It is to be hoped that the boys and girls who have become interested in the Babcock test will continue their interest in dairy subjects this summer. If milk is skimmed on their farms, they should test the skimmed milk to see whether all the fat has been removed in the cream. If they have no testing outfit, they may send samples of skimmed milk to us here, and we will test them, and report the result without charge. When a sample is sent, it should be in a three or four ounce bottle, filled completely full. It should be sweet when placed in the bottle, and have enough potassium bichromate added to give it a distinct color. This substance will prevent the sample from souring and becoming thick. It may be obtained from a drug store. The bottle should be carefully packed in a larger package, and forwarded by mail or prepaid express, to the Department of Dairy Industry. The name and address of the sender should be sent at the same time to notify us that the sample is coming.

PLAYS AND GAMES FOR COUNTRY CHILDREN

By Myron T. Scudder

Principal State Normal School, New Paltz, N. Y

Two years ago a few men and women met in Washington and organized the Playground Association of America. This Association already has a strong membership and is of wide usefulness. Evidently the country was ready for it. Among the honorary officers and active members we note the names of President Roosevelt, Mr. Jacob Riis, Miss

Jane Addams, and Mrs. Humphrey Ward. The Association has headquarters at 624 Madison Avenue, New York, with a strong official staff, at the head of which as President is Dr. Luther Gulick, Supervisor of Physical Training for New York City. These facts are mentioned to show that the playground movement has dignified support, that the playground is to be a growing factor in education, and that play, organized play, play for young and for old, is recognized as one of the fundamental needs of humanity, one of the most important concerns of life.

WHAT PROMINENT MEN HAVE SAID ABOUT PLAY

Ponder upon these quotations.

"Man is wholly man only when he plays."—Schiller.

"Play is the purest and most spiritual activity of man. It holds the source of all that is good. The plays of children are the germinal leaves of all later life."—Froebel.

"The impulse to play is as natural and normal as the inclination to sleep or the desire to eat; and, when we learn its meaning, we see that it is not simply a permissible thing but a divinely ordered thing."—
Dr. Josiah Strong.

"A lack of the proper sort of play unfits a boy for the battle of life."
—Beard.

"The boy without a playground is likely to be father to the man without a job."—Lee.

"It is doubtful if a great man ever accomplished his life work without having reached a play interest in it."

"I hope that soon all of our public schools will provide in connection with the school buildings, and during school hours, a place and time for the recreation as well as study of children. Older children who would play vigorous games must have places specially set aside for them, and since play is a fundamental need, playgrounds should be provided for every child as much as schools."—President Roosevelt.

PLAY IS THE RIGHTFUL HERITAGE OF COUNTRY CHILDREN AS WELL AS OF CITY CHILDREN

Now all that has been said above applies to the country as well as to the city. The Playground Association of America recognizes this and has a committee on rural playgrounds of which the author of this article is chairman. To promote play in rural districts and to give helpful suggestions and advice in the matter of equipping playgrounds is the function of this committee. The opportunity is welcomed to

put forth a series of articles not only to emphasize the importance of play, but to describe some of the many games and occupations which are easily available for people living in country districts.

FIELD DAYS AND PLAY PICNICS IN THE COUNTRY

Reference may be made here to the great Field Days and Play Picnics held at New Paltz, N. Y. under the auspices of the State Normal School solely for country children, their parents and friends. The Country School Athletic League organized two years ago had more than 1,000 people at its first Field Day, about 3,000 at the second meet last June, and is preparing to entertain even a larger number this coming June 13th. This League emphasizes the value of play for country children. It holds that properly supervised play is one of the important concerns of every household, of every school, and of every community. Play makes for health and contentment: it aids in the development of a wholesome social spirit, and of a more kindly community life; it stirs the mind to keen activity and trains the individual to take the initiative, to act promptly and energetically, and to co-operate for the good of all. To bring many of our country communities into pleasant social contact, and to give our people, young and old, opportunity to participate in time-honored sports and amusements, to learn new and inspiring games, and to become acquainted with good, practicable methods of physical training, is the purpose of these Field Days in Ulster County.

Those who would like to know more about this project are invited to send to the Playground Association of America for a copy of "The Field Day and Play Picnic for Country Schools," a monograph prepared by the author of this article to show how a play day for country children can be organized and carried out. Enclose six cents in stamps. This monograph includes also a list of good books on the subject of Athletics and Play.

THE WIDER MEANING OF THE WORDS PLAY AND PLAYGROUND

The words playground and play, as they are now employed, have a wider meaning than is commonly accorded them. It has been suggested that the playground as it is now conceived, ought to be called the "outdoor school," for such it really is, while the meaning of the word play must be extended to include all the means of profitably passing one's leisure or recreation hours. An adequate program of play would include pleasurable outdoor and indoor occupation, for (a) homes, (b) day

schools, (c) Sunday schools, (d) other social organizations, public and private, suitable for Sundays as well as for week days, adjusted to the season of the year, and adapted to the needs of (1) very little children, (2) children from eight to thirteen, (3) boys and girls in the adolescent period, (4) adults; sex as well as age being taken into account when necessary. The word play thus broadened brings us into the realm of kindergartens, manual training departments, vacation schools, summer camps, boys' clubs, girls' clubs, nature-study clubs, camera clubs, collection clubs: it has to do with swimming, fishing, boating, skating, skeeing, and snow-shoeing; also with all forms of athletics; with the use of tools and implements, with the use of clay, plasticine, paper pulp, and putty for modeling; with the use of tops and marbles, bean bags, balls and kites, stilts, toys, soap bubbles, cards, dissected maps, scrap books, and the myriad other amusement materials, plays, and games which are the heritage of the human race, and without sharing in which no child can grow to complete manhood or womanhood, and no adult can live a cheerful, joyous, well-rounded out life. A fine course of study can be formed out of the play occupations given above, a course that would train mind as well as body, and that would give the best kind of preparation for life's serious duties. It must be remembered that learning to play well teaches us how to work well.

HOW TO BECOME BETTER INFORMED

If anyone wishes to inform himself more fully about these things, let him buy Johnson's Education by Plays and Games, Ginn & Company, New York, $.80. This is one of the best books on this subject and contains what President G. Stanley Hall speaks of as a "Course of plays and games graded by age from infancy to middle teens, and also analyzed so as to show the chief mental and physical activities involved in and developed by each of them." This book also contains a good bibliography. Other books will be mentioned later in this series of articles.

FUTURE ARTICLES IN THIS SERIES

In future articles we hope to speak of the country playground and its equipment, of the necessity of being able to construct one's own apparatus, of the importance of play as a means of developing ability to co-operate, very much needed by boys and girls; of the value of play as a socializing factor in the country; i.e. as promoting contentment and richer community spirit, of begetting love for the country which will tend to make country life as fascinating and attractive as city life,

and thus helping to check the depopulation of our farming districts. In this connection we hope also to describe a number of games and pleasure-giving occupations, simply stated and illustrated with diagrams or pictures when necessary.

A WORD ABOUT PLAYGROUNDS

Of course every community should have one or more playgrounds or play areas. Indeed every school and every church should have its adjoining playground. The little village of New Paltz, N. Y. has seven play areas, varying in size from one-fourth of an acre to several acres. Do not think that large, expensively laid out fields are necessary. If nothing more can be found than a little space on which to have a sandpile and a swing or two, start with that. The country road can be pressed into service and it is surprising how many places the children will eventually discover, if they have a little encouragement from adults. It must be remembered that the little folks must have a place of their own, and that girls must have a place where they can play apart from the boys.

SUPERVISION

Supervision and refereeing are essential where apparatus is used or where a considerable number of children play together. One or more adults in each community will have to learn how to supervise intelligently. Women frequently make better supervisors than men. Every school teacher should know how to teach plays and games as well as the three Rs. An adequate system of plays is simply impossible unless the older members of the community are ready to do their share.

SOME GOOD OUTDOOR AND INDOOR GAMES

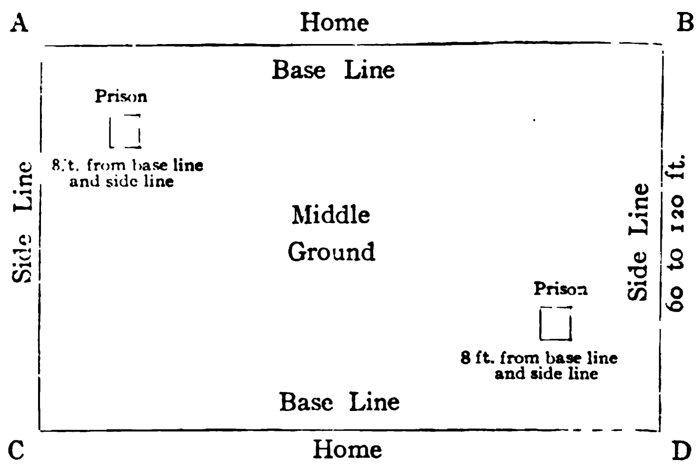
Let us now proceed to describe a few good games. We will start with two outdoor games: Prisoner's Base and Volley Ball; then describe two games (which can be played outdoors or indoors): Indoor Base Ball, and Relay Games; and finally speak of an indoor amusement for young and old on rainy days.

PRISONER'S BASE

This is a game that may be played by all above say seven years of age. The play area may be a wide road, or a fair-sized space in a field. Unevenness of ground or the presence of a few trees need not disturb you. Lay it out as shown in the accompanying diagram, using for the lines slacked

lime or even a row of stones, or a series of lines or marks scratched with a stick or shoe. The base lines AB and CD should be longer than the sidelines AC and BD. On small grounds or when playing across a road the base lines should indeed be very much longer than the side lines. If possible, the base lines should be 75 or 100 feet apart, or even more, for older children but if this distance is not possible make it as great as conditions permit.

The "prisons" may consist of a post, a tree, a stone, or a space marked in any suitable way. They must be located with careful judgment, and, as the game progresses, it may be found necessary to move them nearer or further from the base line, further if it be found that prisoners are being released with too great difficulty, and nearer if they are released so easily that there is no chance for either side to win. If they are placed from six to ten feet outside of the base line, and well over toward the side lines, they will probably be found satisfactory. After all, in laying out the grounds people will have to use common sense and mark out the areas to suit local needs and conditions.



To Play the Game:

1st. Choose sides; any number to a side, but there ought to be at least four.

2nd. The aim of the players is:

(a) To make "runs."

(b) To "capture" an enemy, i.e. a player on the opposite side.

That side wins which has captured all of the other side, or which has the most prisoners after the time appointed for play has expired, say twenty minutes or half an hour, divide into 10 or 15 minute halves. Should the number of prisoners be equal the side which has most runs to its credit wins.

3rd. A run is made by crossing the middle ground and invading the home of the enemy, and then returning without being tagged. When in the enemy's home territory the runner is "safe" for the time being, i.e he may not be tagged; but once in the middle ground either going or coming he may be tagged by any enemy who is "fresh."

A player is "fresh" and is thus qualified to capture a runner of the opposite side when he has left his own base line more recently than the runner of the opposite side left his. A runner, then, becomes "fresh' by returning to his base line for an instant.

Any runner who has made three runs is entitled to a prisoner, i.e. his captain may take any player of the opposite side except the captain, and put him in prison; or he may select to redeem from prison one of his own side who has had the mishap to be caught.

4th. "To capture" an enemy, a player needs simply to tag him. The process is as follows; a runner (it makes no difference who, call him 1A) ventures out from his base and dares anyone from the other side to come out and try to capture him. In reply to 1A's challenge, 1B comes out and gives chase. But suppose now another runner, 2A, dashes out. Since he is "fresh" so far as 1B is concerned, the latter has to give up chasing 1A, and beats a retreat unless in the meantime one of his own side, 2B, should appear on the scene to protect him and to drive 2A back. Back and forth the players go, chasing or being chased as the case may be, depending on whether they are fresh or not, carrying aid to distressed members of their side or running back to their base line to get "fresh" and renew the attack, and occasionally carrying off a prisoner or perhaps making a run. By the way, if while being chased, a runner steps over the side line, he must yield himself a prisoner. And, likewise, if the pursuer runs over the side line *before* he tags the player he is chasing, he also must yield himself a prisoner. In such an event, if the umpire and captains so agree, *both* players may go free instead of going to prison. If either or both should run over the side line *after* the pursuer has tagged the other, the one tagged is prisoner, and no penalty is attached to the other.

5th. When a player is caught, his captor takes him off to prison, where he must stay until rescued by one of his own side. The rescue is made by a successful dash, the runner tagging the prisoner. To aid

in this, the prisoner keeping one foot in prison, may extend his other foot and reach out his hand toward his rescuer. Should there be more than one prisoner, they may form a line, only one needing to keep his foot in prison, and he always the last one caught, and string out towards the rescuer, catching hold of hands or touching feet. Only the one who is tagged is rescued, and unless the rescuer can touch more than one prisoner, the others must wait their turn.

After a capture, and while on the way to prison neither captor nor prisoner may be tagged. So likewise, after a rescue neither party may be tagged while returning to their home. In all cases of capture or rescue, all parties must "freshen" themselves before getting into the game again, and they can neither chase, capture, nor free anybody until they have returned to their base line.

Sometimes in match games between country schools, it has been found that the pupils of one of the schools were too timid or too conservative or lacked vitality, so would not venture far from their base line, in other words, could not be induced to play the game. Under such circumstances the results would be wholly unsatisfactory, and only a half-hearted game would result unless something could be done to stir up the delinquent side. The aggressive side may try to coax them out by making daring runs, but should this not succeed, it may be necessary for the referee to impose some sort of a penalty for inactivity or for refusing to show fight. Of course, for every three runs made by an individual, he is entitled to a prisoner, so it would not be long before the prison of the attacking side would have a number of occupants, and this would tend to arouse the other party into showing greater energy.

FARM BOYS' CLUB.

My dear Boys:

I know that you have your plans all ready for the spring planting and sowing. Your Club has been organized. You have your officers. Your teacher is interested. Your parents are advising you. And, best of all, you have been given a quarter of an acre, more or less, for your own; you are the lord of the estate on that piece of ground. You feel just a little proud in that fact; do you not? You perhaps have wondered, "What can I put on that piece of ground that will pay me well for my effort?" Let me give you a sample of what a boy did in Winnebago County, Illinois. Of course, you know that Illinois is a great corn state. Some of us may want to work with corn, some with potatoes, others with beans and ordinary garden vegetables, and so forth. But let us see what one boy did. Here is Harry McFarland's

report of his own work, taken from Dick J. Crosby's "Boys' Agricultural Clubs."

"My experimental corn was the Leaming corn. I planted my prize growing corn on the 7th of May in a plat that contained three square rods. The soil was a black sandy loam. The ground had garden truck on it last year, which left it in good condition for corn this year. The ground was plowed with a sixteen-inch plow at a depth of six inches. I planted my corn in rows three feet wide, the hills being two feet apart. The corn was up within three days and averaged two stalks to the hill. My corn had a good many suckers on, but very little smut. The corn averaged twelve feet tall, many stalks having two ears on. The work I put on my corn is as follows:

March 30, plowing one-half hour, at 30c. an hour	$0.15
May 6, harrowing one-half hour	.15
May 7, planting one-half hour	.15
May 20, cultivating 15 minutes	.05
June 30, hoeing corn one-half hour	.10
June 23, cultivating	.08
June 30, hoeing	.05
September 25, husking corn	.10
Cost of raising corn	$0.83

The total yield of corn was 2 1-2 bushels. The value of the corn was $3. The gain was $2.17"

Can you beat Harry? We will not be confined to the same crop. We perhaps may have two or three on our little farm.

I am wondering if your teacher will not help you to get ready an exhibit for a fair in your school house this fall? Would it not be rather good fun to have a Friday afternoon given over to a meeting at the school house when the products of the twelve boys in your club are placed on exhibition before the older folks in the neighborhood? You might be able to charge an admission fee of ten cents, so that you could get a little money in the treasury to help buy a few books for your library, or help to pay for baseball bats, catching mitts, and a number of other things that a Boys' Club would like to have. Then at this time your officers whom you have elected will have a splendid opportunity to show their ability to conduct a fair, take up the receipts at the door, and transact all the necessary business. You could have a short literary program, with reports from the exhibitors as to how they grew their products, just as Harry gave his report. Other features could be put

into the program as suggested by your teacher. The prizes for the best exhibit with the best written report, could be awarded at this same time.

Now, do remember to hold meetings regularly during the summer and fall, one a month, to talk about your work and to plan for some good sport, as, for instance, baseball games, or fishing trips, or excursions to good farms.

You will remember that we spoke about having a day of our own at the County Fair. Let each one of us get his father and friends to arrange with the County Fair Association in order that a day may be set aside for our exhibits and for arranging features especially for the New York State Farm Boys' Clubs in your County. Then, too, let us arrange with the Farmers' Institute, that probably will be held near your place, to have a part of the session given over entirely to the Boys' Club. Supposing your officers arrange with the conductor of the Institute to have some work especially for the Club. Then, let some of the boys of the Club give a report at the Farmers' Institute on what they have done. I think it would be fine to have at the Farmers' Institute a number of reports from boys who had grown some good farm crops during the summer. I am sure that the neighborhood would be proud of them. I should like to see scores of boys in the audience listening to these reports that you will make.

This means business. Business means promptness. Send for your seeds at once. With each package of seeds will go special directions for planting. We are arranging now to get high pedigree oats, corn, potatoes, beans. We will also have the vegetable and flower seeds ready for you.

Boys, remember that you are not the only ones who are doing this. There are other boys, in other school districts, and in other counties, who are planning to take up this very same work. They are doing it because they want to work, because they like the fun that will come through the Club, and because they want to get to know other boys in the neighborhood. They want to get one another interested in work and play that will be worth the effort. Do not put it off. If you have not started your Club, do so at once. Get your organization. Send for your seeds, according to the directions in the April leaflet. There is no room in these clubs for the lazy boys. The watch-word is "hustle." Will you be a "hustler?" Write me.

Yours for the boys' club,

CHARLES H. TUCK.

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As I watched these children at their work, I felt repaid for that had been made in developing the garden. They freque the names of certain plants, and going with them to see each on them to describe it. Sometimes obliged to return to the plat or get a more accurate description l could recognize it. This was a lesson in accuracy of observation

FIG. 85—*Chrysalis of cabbage butterfly*

During the afternoon many i observations were made along th animal life. Two stages of the butterfly were found, the larva adult. The children captured and without injuring it in any w able to show them its long tongu way in which it gets nectar flowers. They also found a Viceroy butterfly, and we comp Monarch and the Viceroy, so much alike that close observati part of the children was needed to determine the difference them. We kept on our school grounds a glass globe with netting over it, under which the insects were placed for ob Young children get quite as much benefit from this method of insect study as from mounted specimens.

Our young gardeners were much interested in the toads that were hopping about. They learned that toads would not give them warts, and that they make very interesting pets. When the value of these little creatures in helping to destroy injurious insects was discovered, the boys and girls made effort to keep them on their own garden plats.

FIG. 86—*Cabbage butterfly.* U *male; lower figure fem*

A little "bat" was found asleep upside-down in a sunflower. I told the children that bats earn the privilege of sleeping in the daytime, since, as Professor Hodge expresses it, "They are little night police," and